Contributions to the Classification of the Sea-stars of Japan[1)]
I. Spinulosa[1)]

By

Ryoji Hayashi

Zoological Institute, Faculty of Science, Hokkaido
Imperial University, Sapporo

(With 7 Plates and 63 Textfigures)

Since J. E. Gray's report in 1840, several papers have been published concerning Japanese Asteroidea, but investigation of the animals is still incomplete, especially in respect to the deep water fauna. In 1914 the late Prof. S. Goto published a bulky and elaborate work with detailed descriptions and excellent illustrations of 57 species mostly belonging to the Phanerozonia. He intended to write a second work on Japanese Asteroidea and besides had been preparing a report on the specimens collected in connection with the Albatross Expedition in 1906. His cherished intention was handed over to his pupil T. Uchida together with his rich material and detailed manuscripts for about a dozen species of sea-stars belonging to the Phanerozonia. At the suggestion of Prof. T. Uchida the present author took up the animal group as the object of his investigation. The material and manuscripts have been again transferred, with Uchida's collections and additional notes, to the present writer through the courtesy of Prof. T. Uchida for the latter's investigation.

The present paper is the first report on sea-stars of Japanese waters with the second one now in preparation. These works have been undertaken under the guidance of Prof. T. Uchida and the material used in the studies is chiefly based on Asteroidea of the following collections; the collection of the late Prof. S. Goto; Asteroidea of the "Albatross" Expedition in 1906 and "Sōyōmaru" Expedition in 1926–1930 in the north-western Pacific regions: the collection of the Zoological Institute, Faculty of Science, Hokkaido

1) Contributions from the Akkeshi Marine Biological Station, No. 31.

Imperial University. The writer must express his cordial thanks to Prof. Tohru Uchida for his kind guidance and for placing these collections at the writer's disposal.

Before going further the writer will give a historical review of systematic works on Japanese Asteroidea. The early informations were largely derived from the collection made by Ph. Fr. von Siebold. The first paper was published by J. E. Gray in the Annals and Magazine of Natural History, vol. 6, 1840, containing the following forms, of which localities are uncertain, whether from China or Japan: *Nauricia pulchella* Gray, *Stellaster childreni* Gray=*Stellaster equestris* (Retzius), *Anthenea chinensis* Gray=*Anthenea pentagonula* (Lamark)?. In 1842 J. Müller and F. H. Troschel described the following six forms in their "System der Asteriden": *Asteriscus pectinifera* n. sp.=*Asterina pectinifera* (M. Tr.), *Stellaster childreni* Gray=*Stellaster equestris* (Retzius), *Archaster hesperus* n. sp.=*Craspidaster hesperus* (M. Tr.), *Astropecten armatus* n. sp.=*Astropecten polyacanthus* M. Tr., *Astropecten japonicus* n. sp.=*Astropecten scoparius* Val., *Luidia maculata* n. sp. In 1862 F. Dujardin and H. Hupé, in their "zoophytes èchinodermes", diagnosed seven forms, as follows: *Astropecten japonicus* M. Tr.=*Astropecten scoparius* Val., *Astropecten armatus* M. Tr.=*Astropecten polyacanthus* M. Tr., *Astropecten hesperus* M. Tr.=*Craspidaster hesperus* (M. Tr.), *Stellaster childreni* Gray=*Stellaster equestris* (Retzius), *Asteriscus pectinifera* M. Tr.=*Asterina pectinifera* (M. Tr.), *Luidia maculata* M. Tr., *Nauricia pulchella* Gray. The additional information on Siebold's collection was given by von Martens in the "Ostasiatische Echinoderm" in 1865, as follows: *Asterias rubens* Linné=*Asterias amurensis* (?), *Linckia semiregularis* var. *Japonica* n. var.=*Certonardoa semiregularis* (M. Tr.), *Asterina pectinifera* (M. Tr.), *Astropecten armatus* M. Tr.=*Astropecten polyacanthus* M. Tr., *Luidia maculata* var. *quinaria* n. var.=*Luidia quinaria* v. Martens, *Echinaster* sp., *Stellaster childreni* Gray=*Stellaster equestris* (Retzius), *Archaster typicus* M. Tr., *Stellaster mülleri* n. sp.=*Stellaster equestris* (Retzius), *Archaster hesperus* M. Tr.=*Craspidaster hesperus* (M. Tr)., *Astropecten japonicus* M. Tr.=*Astropecten scoparius* Val., *Nauricia pulchella Gray.* The following forms were diagnosed by J. E. Gray (1866) in his "Synopsis". *Nauricia pulchella* Gray, *Astropecten armatus* M. Tr.=*Astropecten polyacanthus* M. Tr., *Astropecten japonicus* M. Tr.=*Astropecten scoparius* M. Tr., *Luidia maculata* M. Tr.

Stellaster childreni Gray=*Stellaster equestris* (Retzius), *Dorigona Revesii* n. sp.=*Ogmaster capella* M. Tr., *Anthenea pentagonula* (Lamark)?, *Calliaster childreni* Gray, *Palmipes Stokesii* Gray=*Palmipes rosaceus* (Lamark). E. Perrier described in his "Révision", 1876, as follows: *Asterina pectinifera* (M. Tr.), *Stellaster equestris* (Retzius), *Astropecten polyacanthus* M. Tr., *Luidia maculata* M. Tr., *Calliderma emma* Gray. In the Journal of Linnean Society of London, 1879, W. P. Sladen diagnosed the sea-stars of Korean Sea, as follows: *Astropecten formosus* n. sp., *Astropecten japonicus* M. Tr.=*Astropecten scoparius* M. Tr., *Astropecten polyacanthus* M. Tr. *Stellaster Belcheri* Gray=*Stellaster equestris* (Retzius), *Cribrella densispina* n. sp.=*Henricia densispina* (Sladen), *Asteracanthion rubens* var. *migratum* n. va.=*Asterias amurensis* Lütken?. In 1881 F. J. Bell mentioned two new forms of *Asterias* in his "species of *Asterias*": *Asterias rollestoni* n. sp.=*Asterias amurensis* Lütken, *Asterias japonica* n. sp.=*Aphelasterias japonica* (Bell). E. Perrier (1884) described a new form, *Fromia japonica*, which is synonymous with *Fromia monilis* Perrier.

The foregoing works mostly dealt with shore forms. In 1889 W. P. Sladen described the sea-stars on the southeastern coast of Japan, containing deep water forms, in the Asteroidea of the Challenger Expedition. The following forms were reported: *Porcellanaster tuberosus* Sladen, *Hyphalaster inermis* Sladen, *Astropecten japonicus* M. Tr.=*Astropecten scoparius* Val., *Astropecten polyacanthus* M. Tr., *Astropecten brevispinus* Sladen=*Persephonaster brevispinus* (Sladen), *Psilaster gracilis* n. sp.=*Persephonaster gracilis* (Sladen), *Luidia limbata* n. sp.=*Luidia quinaria* v. Martens, *Pararchaster semisquamatus* n. sp.=*Benthopecten spinosus* (Sladen), *Pontaster oxyacanthus* n. sp.=*Cheiraster oxyacanthus* (Sladen), *Pentagonaster japonicus* n. sp.=*Ceramaster japonicus* (Sladen), *Pentagonaster arcuatus* n. sp.=*Mediaster arcuatus* (Sladen), *Asterina penicillaris* (Lam.)=*Asterina batheri* Goto, *Asterina pectinifera* (M. Tr.), *Solaster paxillatus* n. sp., *Hymenaster glaucus* Sladen, *Brisinga armillata* n. sp., *Freyella pennata* n. sp., *Asterias torquata* n. sp.=*Aphelasterias japonica* (Bell), *Asterias stichantha* n. sp.=*Distolasterias stichantha* (Sladen), *Asterias amurensis* Lütken, *Asterias versicolor* n. sp.=*Asterias amurensis versicolor* Sladen. J. E. Ives (1891) listed nine species of sea-stars in the "Echinoderms and Arthropods", remarking as follows: "The southern coast of Japan is washed by the warm waters of the Kuro

Schiwo, the continuation of the north equatorial current of the Pacific. The fauna of this coast is essentially Indo-Pacific, although it possesses many species both of Echinoderms and Crustacean peculiar to it". "The Indo-Pacific species found there must have been carried thither by the Kuro Schiwo, probably in the larval condition". The sea-stars reported by him are given below. *Astropecten armatus* M. Tr.=*Astropecten polyacanthus* M. Tr., *Astropecten japonicus* M. Tr.=*Astropecten formosus* Sladen, *Astropecten scoparius* Val., *Luidia quinaria* v. Martens, *Asterina pectinifera* (M. Tr.), *Nardoa semiregularis* var. *japonica* v. Martens=*Certonardoa semiregularis* (M. Tr.), *Cribrella sanguinolenta* Müller=*Henricia* sp., *Asterias amurensis* Lütken, *Asterias torquata* Sladen=*Aphelasterias japonica* (Bell). M. Meissner (1892) described the following forms in the Arch. f. Naturgesch., 58: *Astropecten latespinosus* n. sp., *Astropecten scoparius* Val., *Luidia limbata* Sladen=*Luidia quinaria* v. Martens, *Asterina pectinifera* (M. Tr.), *Asterias torquata* Sladen= *Aphelasterias japonica* (Bell). In 1895 C. P. Sluiter briefly mentioned about *Asterina pectinifera* deposited in Amsterdam Museum. S. Hirota (1895) described *Linckia multifora* from the Ogasawara Is., with the anatomical note of the species. P. De Loriol in 1899 two new forms of *Astropecten*; *A. kagoshimensis* n. sp. and *A. ludwigi* n. sp., the latter being synonymous with *Astropecten formosus* Sladen. L. Döderlein (1902) described in his "Japanische Seesterne" the following forms: *Asterogonium pretiosum* n. sp.=*Dipsacaster pretiosus* Död., *Astropecten ludwigi* Loriol=*Astropecten formosus* Sladen, *Astropecten scoparius* Val., *Astropecten polyacanthus* M. Tr., *Astropecten kagoshimensis* Loriol, *Astropecten kagoshimensis* var. *kochiana* n. var.=*Astropecten brasiliensis kochianus* Död., *Astropecten latespinosus* Meissner, *Luidia quinaria* v. Martens, *Luidia maculata* M. Tr., *Asterina pectinifera* (M. Tr.), *Nardoa semiregularis* var. *japonica* v. Martens=*Certonardoa semiregularis* (M. Tr.), *Cribrella sanguinolenta* Müller=*Henricia* sp., *Asterias calamaria* var. *japonica* n. var.=*Coscinasterias acutispina* Stimpson, *Asterias volsatella* var. *sakurana* n. var., *Asterias rollestoni* Bell=*Asterias amurensis* Lütken, *Asterias nipon* n. sp.=*Distolasterias nipon* (Död.), *Asterias satsumana* n. sp., *Asterias japonica* Bell=*Aphelasterias japonica* (Bell). H. L. Clark (1908) reported five forms, as follows: *Asterina pectinifera* (M. Tr.), *Pteraster obesus* n. sp., *Pteraster multiporus* n. sp., *Asterias rollestoni* Bell=*Asterias amurensis* Lütken, *Asterias similispinis* n.

sp.=*Leptasterias ochotensis similispinis* (Clark).

W. K. Fisher (1911) published the fine monograph of the North Pacific Asteroidea, part I, in which the following Japanese forms are included: *Ctenodiscus crispatus* (Retzius), *Leptychaster anomalus* Fisher, *Leptychaster arcticus* (Sars), *Pseudarchaster parelii* (Düben & Koren), *Ceramaster japonicus* (Sladen), *Hippasteria spinosa kurilensis* Fisher, *Hippasteria leiopelta armata* Fisher, *Henricia sanguinolenta* (Müller), *Henricia sanguinolenta eschrichtii* Fisher=*Henricia tumida* Verrill, *Henricia leviuscula multispina* Fisher=*Henricia leviuscula spiculifera* (Clark), *Solaster dawsoni* Verrill, *Solaster paxillatus* Sladen, *Solaster borealis* (Fisher), *Solaster japonicus* n. sp.=*Crossaster papposus* forma *japonicus* (Fisher), *Diplopteraster multipes* (Sars).

In 1914 an elaborate work was published by S. Goto, with detailed descriptions of 57 forms and a complete reference of literature concerning Japanese sea-stars. The species described in the paper are as follows: *Archaster typicus* M. Tr., *Benthopecten spinosus* Verrill, *Cheiraster oxyacanthus* (Sladen), *Cheiraster yodomiensis* n. sp., *Ctenodiscus crispatus* (Retzius), *Porcellanaster tuberosus* Sladen, *Hyphalaster inermis* Sladen, *Astropecten scoparius* Val., *Astropecten polyacanthus* M. Tr., *Astropecten ludwigi* Loriol=*Astropecten formosus* Sladen, *Astropecten kagoshimensis* Loriol, *Astropecten latespinosus* Meissner, *Astropecten formosus* Sladen, *Persephonaster asper* n. sp., *Persephonaster misakiensis* n. sp., *Persephonaster triacanthus* n. sp., *Persephonaster brevispinus* (Sladen), *Leptychaster arcticus* (Sars), *Leptychaster anomalus* Fisher, *Dipsacaster grandissimus* n. sp., *Craspidaster hesperus* (M. Tr.), *Psilaster gracilis* Sladen =*Persephonaster gracilis* (Sladen), *Nauricia pulchella* Gray, *Luidia maculata* M. Tr., *Luidia quinaria* v. Martens, *Luidia moroisoana* n. sp., *Luidia yesoensis* n. sp., *Pentagonaster japonicus* Sladen=*Ceramaster japonicus* (Sladen), *Pentagonaster arcuatus* Sladen=*Mediaster arcuatus* (Sladen), *Pentagonaster misakiensis* n. sp., *Hippasteria imperialis* n. sp., *Hippasteria nozawai* n. sp., *Hippasteria spinosa* Verrill, *Mediaster brachiatus* n. sp., *Johannaster giganteus* n. sp., *Pseudarchaster pretiosus* (Död)=*Dipsacaster pretiosus* (Död), *Pseudarchaster parelii* (Düben & Koren), *Stellaster equestris* (Retzius), *Calliaster childreni* Gray, *Calliderma emma* Gray, *Ogmaster capella* (M. Tr), *Anthenea pentagonula* (Lamark), *Oreaster modestus* (Gray)=*Protoreaster nodosus* (Linné), *Oreaster doederleini* n. sp.=

Pentaceraster regulus (M. Tr.) (?), *Oreaster magnificus* n. sp.= *Pentaceraster regulus* (M. Tr.) (?), *Oreaster nahensis* n. sp.= *Protoreaster nodosus* (Linné), *Oreaster nodosus* (Linné)=*Protoreaster nodosus* (Linné), *Oreaster linkii* (Blainville)=*Protoreaster nodosus* (Linné) (?), *Culcita novaeguineae* M. Tr., *Choriaster granulatus* Lütken, *Gymnasteria carinifera* (Lamark)=*Asterope carinifera* (Lamark), *Asterina pectinifera* (M. Tr.), *Asterina novaezelandiae* Perrier=*Asterina coronata* forma *japonica, Asterina batheri* n. sp., *Palmipes tenuis* n. sp., *Palmipes petaloides* n. sp., *Palmipes rosaceus* (Lamark). A. E. Verrill diagnosed the following forms in the monograph in 1914: *Heterasterias volsellata* (Sladen), *Coscinsterias acutispina* Stimpson, *Distolasterias stichantha* (Sladen), *Allasterias forficulosa* Verrill=*Asterias amurensis* Lütken, *Allasterias versicolor* (Sladen)=*Asterias versicolor* Sladen, *Allasterias migrata* (Sladen)=*Asterias amurensis* Lütken (?), *Henricia densispina* (Sladen), *Henricia japonica* n. sp. In L. Döderlein's report (1917) on Astropectinidae of the Siboga Expedition, the following Japanese species were described: *Astropecten brevispinus* Sladen=*Persephonaster brevispinus* (Sladen), *Astropecten formosus* Sladen, *Astropecten sagaminus* n. sp., *Astropecten brasiliensis kochianus* Död., *Astropecten latespinosus* Meissner, *Astropecten gisselbrechti* n. sp., *Astropecten polyacanthus* M. Tr., *Astropecten carcharicus formosus* n. subsp., *Astropecten kagoshimensis Loriol, Astropecten scoparius* Val. In the same series L. Doderlein (1920) diagnosed Japanese *Luidia,* as follows: *Luidia avicularia* Fisher, *Luidia inarmata* n. sp., *Luidia quinaria* v. Martens, *Luidia sagamina* n. sp., *Luidia maculata* M. Tr. W. K. Fisher (1924) described a remarkable sea-star, *Lysastrosoma anthosticta,* from Muroran. In the same year T. Uchida reported sea-stars of Mutsu Bay, as follows: *Astropecten scoparius* Val., *Luidia quinaria* v. Martens, *Luidia yesoensis* Goto, *Patiria pectinifera* (M. Tr.)=*Asterina pectinifera* (M. Tr.), *Henricia sanguinolenta* (Müller), *Henricia leviuscula* (Stimpson), *Henricia leviuscula* var. *multispina* Fisher, *Henricia leviuscula* var. *nipponica* n. var., *Solaster dawsoni* Verrill, *Asterias rollestoni* Bell=*Asterias amurensis* Lütken, *Asterias nipon* Död.=*Distolasterias nipon* (Död.), *Aphelasterias japonica* (Bell) *Labidiaster borealis* n. sp. A. M. Djakonov (1929) described a new sea-star, *Luidiaster tuberculatus,* from the nothern Japan Sea. In 1930 the same author diagnosed sea-stars of Okinawa, Ryukyu Is., as follows: *Anthenea flavescence*

var. *nuda* Döderlein, *Culcita novaeguineae* M. Tr., *Oreaster nodosus* (Linné)=*Protoreaster nodosus* (Linné), *Nardoa obtusa* Perrier=*Nardoa tuberculosa* forma *obtusa* Perrier, *Linckia laevigata* (Linné), *Linckia multifora* (Lamark), *Linckia guildingii* Gray, *Ferdina intermedia* n. sp., *Patiriella exigua* (Lamark)=*Asterina exigua* (Lam.), *Othilia purpurea* Gray=*Echinaster luzonicus* (Gray). In 1928 and 1930 W. K. Fisher's monograph of the North Pacific Asteroidea, parts II and III, were published, in which the following forms are reported: *Distolasterias nipon* (Död.), *Lysastrosoma anthosticta* Fisher, *Aphelasterias japonica* (Bell), *Aphelasterias japonica* forma *torquata* (Sladen)=*Aphelasterias japonica* (Bell), *Asterias amurensis rollestoni* Bell=*Asterias amurensis* Lütken, *Asterias amurensis migrata* (Sladen)=*Asterias amurensis* Lütken (?), *Asterias versicolor* Sladen=*Asterias amurensis versicolor* Sladen, *Leptasterias ochotensis similispinis* (Clark), *Leptasterias orientalis* Djakonov, *Leptasterias camtschatica* (Brandt), *Leptasterias alaskensis asiatica* Fisher. H. Ohshima (1930) recorded *Oreaster doederleini* from Amakusa, which is probably referable to *Pentaceraster regulus*. A. M. Djakonov (1931) reported a new sea-star, *Lethasterias fusca*, from Rebun Id. and in the next year a new sea-star, *Solaster diamesus*, from the nothern Japan Sea. In 1931 T. Uchida described a new sea-star, *Pteraster japonicus* from the northern Japan Sea. In 1935 H. Ohshima reported sea-stars of Yaeyama, Ryukyu Is., as follows: *Oreaster australis* Lütken=*Pentaceraster regulus* forma *cebuana* Död. *Pentaceropsis tyloderma* Fisher=*Pentaster obtusatus* (Bory de Saint Vincent), *Choriaster granulatus* Lütken, *Asterope carinifera* (Lamark), *Nardoa frianti* Koeler=*Nardoa tuberculata* forma *obtusa* (Perrier), *Leiaster brevispinus* Clark=*Leiaster leachii* Gray, *Fromia milleporella* (Lamark), *Acanthaster planci* (Linné), *Archaster typicus* M. Tr., *Linckia laevigata* (Linné). In 1935 and 1936 L. Döderlein studing Oreasteridae of the Siboga Expedition treated with the following Japanese species: *Stellaster equestris* (Retzius), *Ogmaster capella* M. Tr., *Anthenea flavescence* var. *nuda* Död., *Culcita novaeguineae* M. Tr., *Choriaster granulatus* Lütken, *Protoreaster nodulosus* Perrier, *Protoreaster nodosus* (Linné), *Protoreaster lincki* Blainville, *Protoreaster gotoi* n. sp.=*Protoreaster nodosus* (Linné), *Pentaceraster japonicus* Död., *Pentaceraster magnificus* Goto=*Pentaceraster regulus* M. Tr. (?). In 1935 R. Hayashi reported *Henricia sanguinolenta* var. *Ohshimai* n. var. from Amakusa and

in 1936 studied the variation of *Asterias amurenis* Lütken, and further in 1937 described the variation of *Oreaster nodosus*=*Protoreaster nodosus*. In 1938 T. Kamita recorded the sea-stars of Korean coasts identified by Hayashi, as follows: *Ctenodiscus crispatus* (Retzius), *Luidia yesoensis* Goto?, *Pseudarchaster* sp., *Certonardoa semiregularis* (M. Tr.), *Patiria pectinifera* (M. Tr.)=*Asterina pectinifera* (M. Tr.), *Asterias rollestoni* Bell=*Asterias amurensis* Lütken, *Coscinasterias calamaria* Gray=*Coscinasterias acutispina* Stimpson, *Labidiaster borealis* Uchida. R. Hayashi (1938) described sea-stars of the Caroline Islands as follows: *Archaster typicus* M. Tr., *Protoreaster nodosus* (Linné), *Culcita novaeguineae* Lütken, *Choriaster granulatus* Lütken, *Asterope carinifera* (Lamark), *Fromia monilis* Perrier, *Fromia indica* forma *andamanensis* Koehler, *Nardoa tuberculata* Gray, *Nardoa tuberculata* forma *pauciforis* (v. Martens), *Nardoa tumulosa* Fisher, *Linckia laevigata* (Linné), *Linckia multifora* (Lamark), *Linckia diplax* (M. Tr.), *Ophidiaster granifer* Lütken, *Patiriella exigua* (Lamark), *Acanthaster luzonicus* (Gray), *Acanthaster planci* (Linné). R. Hayashi (1938) reported the following sea-stars from the Ogasawara Is.; *Fromia indica* Perrier, *Nardoa frianti Koehler, Ophidiaster cribrarius* Lütken, *Linckia multifora* (Lamark), *Echinaster luzonicus* (Gray), *Coscinasterias acutispina* (Stimpson). The same author (1938) recorded sea-stars of Toyama Bay, as follows: *Ctenodiscus crispatus* (Retzius), *Astropecten scoparius* Val., *Astropecten kagoshimensis* de Loriol, *Astropecten latespinosus* Meissner, *Ctenopleura ludwigi* (de Loriol)=*Astropecten formosus* Sladen, *Luidia quinaria* v. Martens, *Luidia yesoensis* Goto, *Pseudarchaster pretiosus* (Död.)=*Dipsacaster pretiosus* (Död.), *Psudarchaster parelii* (Düben & Koren), *Fromia indica* Perrier, *Linckia multifora* (Lamark), *Certonardoa semiregularis* (M. Tr.), *Asterina batheri* Goto, *Patiria pectinifera* (M. Tr.)=*Asterina pectinifera* (M. Tr.) *Crossaster papposus* (Linné), *Echinaster luzonicus* (Gray), *Henricia* sp., *Asterias amurensis* var. *versicolor* Sladen, *Aphelasterias japonica* (Bell), *Coscinasterias acutispina* Stimpson. R. Hayashi (1938) described sea-stars of the Ryukyu Is., as follows: *Pentaceraster regulus* forma *cebuana* Död., *Pentaster obtusatus* (Bory de Saint Vincent), *Asterope carinifera* (Lamark), *Fromia milleporella* (Lamark), *Fromia monilis* Perrier, *Fromia indica* Perrier, *Fromia hadracantha* Clark, *Nardoa tuberculata* forma *obtusa* (Perrier), *Nardoa tumulosa* Fisher, *Linckia laevigata* (Linné),

Linckia multifora (Lamark), *Leiaster leachii* (Gray), *Ophidiaster granifer* Lütken, *Ophidiaster pustulatus* (v. Martens), *Asterina* sp., *Asterina coronata* v. Martens, *Echinaster luzonicus* (Gray), *Mithrodia clavigera* (Lamark), *Coscinasterias acutispina* Stimpson. R. Hayashi (1938) reported the following sea-stars in the vicinity of the Seto Marine Biological Laboratory: *Astropecten scoparius* Val., *Astropecten polyacanthus* M. Tr., *Astropecten kagoshimensis* de Loriol, *Astropecten latespinosus* Meissner, *Persephonaster setoensis* n. sp., *Luidia quinaria* v. Martens, *Luidia maculata* M. Tr., *Asterodiscus Hiroi* n. sp., *Fromia indica* Perrier, *Fromia monilis* Koehler, *Certonardoa semiregularis* (M. Tr.), *Ophidiaster lorioli* Fisher?, *Leiaster grandis* n. sp., *Linckia guildingii* Gray, *Asterina coronata* v. Martens, *Asterina batheri* Goto, *Patiria pectinifera* (M. Tr.)=*Asterina pectinifera* (M. Tr.), *Mithrodia clavigera* (Lamark), *Pteraster tesselatus* Ives, *Asterias amurensis* Lütken, *Coscinasterias acutispina* Stimpson. W. K. Fisher diagnosed a new sea-star, *Poraniopsis japonicus*, in 1939. In the same year R. Hayashi published a paper on Solasterids in Japanese waters, including the following forms: *Solaster endeca* (Linné), *Solaster stimpsoni* Verrill, *Solaster dawsoni* Verrill, *Solaster dawsoni* var, *intermedius* n. var., *Solaster diamesus* Djakonov, *Solaster borealis* Fisher, *Solaster Uchidai* n. sp., *Crossaster papposus* (Linné), *Crossaster papposus* forma *japonicus* (Fisher).

Order SPINULOSA PERRIER

The order is sharply separated from the Forcipulata by the absence of the characteristic crossed pedicellariae, but poorly from the Phanerozonia. In Japanese waters are included six families of the order.

Aboral skeleton reticulated or imbricated. Aboral spines usually numerous, isolated or in groups forming fascicules and pseudopaxillae. Marginal plates inconspicuous. Papulae only on dorsal side or also on intermarginal and ventrolateral. Ambulacral plates not crowded and compressed. Pedicellariae rare, never forcipiform. Tube-feet usually in two rows, rarely in four, with well developed terminal sucker and single or double ampullae. Polian vesicles present or absent. Mouth plates medium-sized or large.

Key to Japanese families of Spinulosa

a^1. Mouth plates rather small, not spade-shaped or plowshere-shaped; the furrow narrow.

b^1. Marginal plates inconspicuous.

c^1. Aboral skeleton formed of closely imbricating plates bearing small spines; ventrolateral skeleton composed of imbricating plates bearing a tuft or a fan of spinelets; ventrolateral papulae absent..... **Asterinidae**

c^2. Aboral skeleton formed of plates froming somewhat regular or irregular mesh works, more or less open; the plates bearing isolated spines or groups of spinelsts, but ventrolateral spinelets not fan-shaped.

d^1. Ampulae single; no pedicellariae; interbrachial septa weak, more or less rudimentary; aboral plates reticulated irregularly, bearing solitary spinelets or groups of spinelets or large isolated spines ..... **Echinasteridae**

d^2. Ampullae double; pedicellariae present; interbrachial septa present or absent; aboral spines prominent, covered with skin containing granules.

e^1. Disc small, no interbrachial speta; pedicellariae not usually present, when present, the organ with several small recurved teeth; skeletal reticulation roughly in the form of triangles grouped in hexagon; large obtuse spines beset with rough scales or spinelets. ..... **Mithrodiidae**

e^2. Disc large; rays numerous; numerous madreporites; pedicellariae with two upright tapering jaws numerous; skeleton open meshed; spines large, isolated..... **Acanthasteridae**

a^2. Mouth plates large, spade-shaped or plowshere-shaped; the furrow wide.

b^1. Marginal plates paxilliform, in one or two series; aboral paxillae never with long spines, but fascicular or pencillate; mouth plates spade-shaped; ventrolateral plates present; adambulacral armature in two series at right angle; interbrachial septa. ..... **Solasteridae**

b^2. A complete supradorsal membrane forming a special nidamental cavity; segmental pore and papillae; interbrachial septa not calcified; ventrolateral spines present; ventrolateral plates absent; mouth plate plowshere-shaped; adambulacral armature in transverse series. **Pterasteridae**

Family Asterinidae GRAY, 1840

Asterinidae: GRAY, 1840, p. 228; FISHER, 1911, p. 253.

Body stellato-pentagonal in form, with sharp angular margin. Aboral plates imbricated, regularly arranged, except those in papular areas, bearing small spinelets in groups or tufts. Ventrolateral

plates regularly arranged, with a single or a few spinelets. Marginal plates inconspicuous. Adambulacral spines arranged in two parallel series.

The old genus *Asterina* was divided by Verrill ('13) in six genera; *Asterina, Asterinides, Patiria, Patiriella, Asterinopsis* and *Enoplopatiria.* A few years after Fisher ('19) reduced these genera to four; *Asterina* (Verrill's *Asterina* + *Asterinides*), *Patiria* (*Patiria* + *Enoplopatiria*), *Patiriella* and *Asterinopsis.* The following four genera of the family are known from Japanese waters; *Asterina Patiria, Patiriella* and *Palmipes.* The differences of the former three genera will be summerized in the following table.

Genera	Aboral plates	Ventrolateral plates	Pedicellariae
Asterina	Aborals in papular areas all of one kind.	Each with a group of spines, 5 more or less.	Present or absent.
Patiria	Aborals of 2 or more diverse kinds.	Each with a fan-shaped group of 2–8 spines.	Present or absent.
Patiriella	Aborals of 2 or more diverse kinds, accessory plates fewer than in *Patiria.*	Each with 1, sometimes 2 spines.	Absent.

The writer is of opinion that these differences cannot be valued as generic characters, inferring from the facts which will be stated in the following: The accessory aboral plates of *P. pectinifera* are variable in number with growth and even in the adult divergent in size. In young specimens of this species they are confined only to the proximal midradial portions of rays and very much fewer than in the adult. Besides, it must be noted that species belonging to *Patiria* are rather large, while those belonging to *Patiriella* and *Asterina* are rather small in size. On the other hand, when much importance is attached to the aboral skeleton and spinulation as generic values, *A. coronata*[1] must be separated as a distinct genus from *A. batheri,* because the former species has the aboral skeleton composed of two kinds of plates, principal and accessory, while the latter has the skeleton mostly consisted of principal plates, though with few accessory ones. Therefore, *Patiria* and *Patiriella* should be

1) *Asterina coronata* forma *japonica* in the present paper.

merged into *Asterina*. The ventral location of genital pores as seen in *A. gibbosa* does not always occur in *Asterina*, because they open dorsally in *A. batheri* and *A. coronata*.

Key to Japanese genera of Asterinidae

Body stellato-pentagonal to pentagonal in form.

a¹. Disc arched, moderately thick; aboral plates in papular area arranged regularly; aborals all of one kind or of two or more kinds; ventrolateral plates each with a single isolated spines or 2 to 8 (10) spines in a fan-shaped series or in cluster. ..... ***Asterina*** NARDO

a². Body thin and flat; aboral plates in papular areas various in size and form, without any definite order; ventrolaterals each with 3–10 spinelets in a curved series. ..... ***Palmipes*** LINCK

Genus *Asterina* NARDO

Asterina: NARDO, 1834, p. 716. Type, *Asterias minuta* Nardo-*Asterias gibbosa* PENNENT; VERRILL, 1913, pp. 477–485; FISHER, 1911, p. 254; ——, 1919, p. 408.

Patiria: GRAY, 1940, p. 290. Type, *p. coccinea* (GRAY); VERRILL, 1913, pp. 480, 482.

Patiriella: VERRILL, 1913, pp. 480, 483. Type, *Patiria regulus* (VERRILL); FISHER, 1919, pp. 410, 416.

Key to Japanese species of *Asterina*

Body pentagonal to stellato-pentagonal, disc arched; oral side flat.

a¹. No prominent tuberculated aboral plates.

b¹. Stellato-pentagonal form; aboral plates in papular areas all of one kind, very regularly arranged; ventrolaterals each with 3 to 7 spines in a group. ..... ***batheri***

b². Subpentagonal form; aboral plates of two or more diverse kinds.

c¹. Accessory aborals numerous; ventrolaterals each with 5–6 (4–10) spines in a fan-shaped group. ..... ***pectinifera***

c². Accessory aborals much fewer than in *pectinifera*; ventrolaterals each with a single spine, sometimes 2; small areas behind mouth free from spines. ..... ***exigua***

a². Some of principal aboral plates prominently tuberculated; accessory aborals much fewer than in *pectinfera*; ventrolaterals each with 3 (2–8) spines in a group; spinulation coarser than in *batheri;* stellato-pentagonal form. ..... ***japonica***

Asterina batheri GOTO

(Pl. 13, figs. 5, 6.)

Asterina batheri: GOTO, 1914, p. 651, pl. 19, figs. 275–278.
Asterina penicillaris: SLADEN, 1889, p. 393.

The present species is common near the tidal lines on the southern coasts of Japan.

Diagnosis. Body stellato-pentagonal in form; disc elevated; oral side flat; R. about 2r. Aboral skeleton composed of plates all of one kind; the plates are large, crescentic or subcordate in form, strictly concaved for papular areas, arranged very regularly in longiseries, forming V-shaped series with those of the adjacent rays. In the proximal portion of ray the carinal plates are a little larger than the laterals, with two concaved faces, one for each papular area; those near body margin small, where papulae absent. Aborals each with 7 to 15 small spinelets. Papular areas distinctly isolated, with a single papula in an area. Ventrolateral plates regularly arranged in rows parallel to the furrow, each with 3 to 7 pointed spinelets in a group. Adambulacral plates each with 3 to 7 spines in a curved fan-like furrow series, the middle 2 or 3 spines larger than the laterals; behind the series is located a slightly smaller curved series of 6–7 spines. Mouth plates with 6–8 furrow spines gradually decreasing from mouth; suboral spines 5 to 6 in a series and 2 or 3 smaller spinelets.

Localities. Amakusa, Seto and Toyama Bay.
Distribution. Southern coast of Japan.

Asterina coronata forma *japonica* n. forma

(Pl. 11, figs. 5, 6, 7, & Pl. 13, fig. 7.)

Asterina novae-zealandiae: GOTO, 1914, p. 643, pl. 19, figs. 273–281.
Asterina coronata coronata: FISHER, 1919, p. 414.
Asterina coronata: HAYASHI, 1938, p. 215.

The small Japanese sea-star is a related species to Goto's *batheri*. Concerning Goto's *A. novae-zealandiae=Patiria novae-zealandiae* of Verrill ('13), Fisher ('19) remarks that "Dr. Seitaro Goto, in his work on Japanese Asteroidea, carefully figures and describes a species from southern parts of Kyusyu and adjacent

islands which he calls *Asterina novae-zealandiae* Perrier, but which I believe is a form of *coronata*, as it possesses the prominent abactinal plates so characteristic of *coronata*."

So far as the writer examined at Amakusa and Seto, the prominent aboral plates are considerably variable in number, in individuals, sometimes absent. From the related species, *A. batheri*, they differ in having prominent tuberculated aboral plates; the conspicuous central ring on disc, probably represented by primary radial and interradial plates; the aboral plates being not arranged so regularly as in *batheri*; and much coarser spinulation. More distinguishable feature than those above mentioned is the aboral skeleton which is composed of two or more diverse kinds of plates, principal and accessory. In this point Japanese specimens of *A. coronata* are different from *A. batheri* and *A. coronata coronata* and seem to be a new form of the type species.

Diagnosis. Body stellato-pentagonal in form, quite similar to *batheri*. Aboral plates of two or more diverse kinds; principal plates shield-like, thick, crescentic in form, arranged in regular longiseries, though the series being irregular by having a large number of much tuberculated principal plates. The spinulation of plates is much coarser than in *batheri*, and the paxillae are slightly more widely spaced. The prominent aborals are very diverse in number and position and sometimes entirely absent. Each plate bears 20–30 much stouter spines than those of others. The nonprominent principal plates have each 10 to 15 spines at the adcentral border. The accessory plates in proximal papular areas are roundish or rod-like in form, each with about 2 to 8 spines according to size of plates. The central ring on disc representing the apical system is conspicuous. Ventrolateral plates arranged in regular V-shaped series, each with 3–4 (2–8) spines. Adambulacral plates armed with two series of spines; furrow series of 4–6 spines, 1 or 2 laterals being smaller; subambulacral series of 3–5 spines. Mouth plates each with 7–8 spines and 5–6 suboral spines.

Localities. Amakusa, Seto and Kakeroma, Amamiōsima.

Distribution. Southern Pacific coast of Japan and Kyusyu and Amamiōshima.

Asterina exigua (LAMARK)

Asterias exigua: LAMARK, 1816, p. 554.
Asterina exigua: PERRIER, 1875, p. 302; KOEHLER, 1910, p. 129, pl. 9, figs. 6, 7.
Patiriella exigua: FISHER, 1919, p. 416, pl. 109, figs. 3, 4; DJAKONOV, 1930, p. 251: HAYASHI, 1938, p. 439, pl. 3, figs. 5, 6.

Diagnosis. Body subpentagonal; rays 4 to 6 (examined specimen 6-rayed); aboral plates of two kinds; principal plates each with 7 to 14 small granular spinelets, strongly concaved for papular areas, arranged in longiseries; accessory plates in papular areas much smaller, each with 2–5 spinelets; papulae separated. Marginal plates indistinct. Ventrolateral plates regularly arranged in V-shaped series, each with an acute spinelet, sometimes two; spinelets are wanting on small areas behind mouth plates, where ventrolaterals large and spaced. Adambulacral plates with 2 series of spines; 2 or 3 (4) acute furrow spines and 1 coarser subambulacral spine; mouth plates each with 5 or 6 longer furrows and 1 or 2 suborals.

Locality. Palao Islands.

Distribution. Common in the Indo-Pacific; Palao and Ryukyu Islands in Japan.

Asterina pectinifera MÜLLER & TROSCHEL

Asteriscus pectinifera: MÜLLER & TROSCHEL, 1842, p. 40.
Asterina pectinifera: GOTO, 1914, p. 643, pl. 18. figs. 272–273, pl. 19, fig. 274.
Patiria pectinifera: FISHER, 1919, p. 410; UCHIDA, 1928, p. 788; HAYASHI, 1938, p. 116; ——, 1938, p. 287.

The present species is one of common sea-stars in Japan. Goto ('14) described the species in detail in his monograph.

Diagnosis. Rays generally 5; variable in number, 4 to 9. Body subpentagonal in form; aboral side arched; oral side flattened. Aboral skeleton composed of two kinds of plates: Principal plates large, crescentic shaped or elongated, arranged in longiseries at dorsolateral sides of ray, forming V-shaped series with those of the adjacent rays. Principal plates each with granuliform spinelets, 30 to 20 or less, according to the size of plates; accessory plates very

much smaller than principals, rounded or elliptical in form, subdividing papular areas, with 5 to 15 slightly slender and shorter spinelets. Papulae 3–5 (1–10 or more) in an area, each separated. Along the margin of body aboral plates small, nearly uniform in size, densely crowded, forming a band-like portion, free from papulae; marginal plates inconspicuous. Ventrolateral plates rounded or elliptical, decreasing in size toward body margin; each with 5–6 (4–10) somewhat flattened subequal spinelets, generally arranged in a fan-shaped series. Adambulacral plates with two series of spines: Furrow series mostly with 3 (4) stout, flattened, truncated spines, the adoral one being occasionally smaller; subambulacral series with 4 to 6 spines in a slightly oblique curved series, the aboral 2 or 3 mostly stouter than the rest. Mouth plates each with 5–6 oral spines, the innermost one being exceedingly large, occasionally more than twice as broad as the next; the outer series with 5–6 graduated spines.

Note on young specimens (R 14 to 20 mm) Dorsolateral plates each with 10–15 spinelets which are regularly arranged in longiseries, forming V-shaped series with those of adjacent rays; the triangular areas concaved on marginal side are free from papulae or accessory plates which are confined to the proximal midradial portion of rays and disc. Adambulacral plates each with 3 furrow spines, the adoral one being smaller; subambulacral spines also 3, slightly shorter than furrow ones. Mouth plates with 5–6 furrow spines, gradually decreasing from mouth, the first and second ones never so broad and stout as in adult specimens; 4 or 5 suborals in a series. Ventrolatral plates each with 2–4 spinelets.

Distribution. Common in Hokkaido to Kyusyu to Korea.

Family Echinasteridae VERRILL, 1867, restricted

Echinasteridae: VERRILL, 1867, p. 343; FISHER, 1911 p. 258.

Aboral skeleton more or less open-meshed; small imbricating plates variable in form. Skin covering the plates, thin or thick; spines isolated or grouped in pseudopaxillae. No pedicellariae. Tube-feet in two series, each with a single ampulla. Interbrachial septa weak, more or less rudimentary. In Japanese waters three genera are known; *Henricia, Poraniopsis* and *Echinaster*.

Key to Japanese genera of Echinasteridae

a^1. Aboral and marginal plates with small spinelets in groups, skin covering plates generally not thick, but rarely rather thick; spinelets never large and isolated; ventrolateral plates and papulae usually present.... ***Henricia*** GRAY

a^2. Aboral and marginal plates covered with a rather thick skin, bearing simple isolated spines, no ventrolateral papulae.

b^1. Papular areas very large, containing numerous papulae; spines large, prominent; no spines deep in furrow; rays wide and short..... ..... ***Poraniopsis*** PERRIER

b^2. Papular areas small; spines not prominent; single spinelets deep in furrow; rays long and slender. ..... ***Echinaster*** M. TR.

Genus *Echinaster* MÜLLER & TROSCHEL

Echinaster: MÜLLER & TROSCHEL, 1840, p. 102; ——, 1840, p. 321; FISHER, 1911, p. 260; VERRILL, 1914, p. 206; FISHER, 1919, p. 426.

Echinaster luzonicus (GRAY)

Echinaster luzonicus: CLARK, 1921, p. 98, figs. 2–4; LIVINGSTONE, 1932, p. 262; HAYASHI, 1938, p. 66; ——, 1938, p. 440, pl. 3, figs. 5, 6; ——, 1938, p. 215.

Othilia purpurea: DJAKONOV, 1930, p. 251.

The present species is common in Palao and lives on sides of or under reef rocks near the low tide line. The colour in life is variable, dark brown, blackish brown, reddish brown, dark red or flesh red and in alcohol brownish.

Diagnosis. Body covered with a thick skin. Disc small, rays long, variable in number 4 to 7, generally 6. Aboral skeleton forming a roundish irregular meshwork, papular areas small. Aboral spines small, isolated and ventrolateral plates and papulae absent. Adambulacral plates with three spines in a transverse row, the one situated deep in furrow. Madreporite generally two. The measurements were already given by the writer, as follows:

R	r	R:r	Locality
32mm–50mm	9mm	3.5–5.5	Ogasawara Is.
19mm	6mm	3.1	Ogasawara Is.
27mm–45mm	10mm	2.7–4.5	Toyama Bay
25mm–48mm	9mm	2.8–5.3	Yaeyama Is.
42mm–47mm	8.5mm	4.9–5.5	Yaeyama Is.
52mm	9mm	5.8	Yaeyama Is.

R	r	R : r	Locality
27mm–68mm	10mm	2.7–6.8	Okinawa Is.
32mm–48mm	9mm	2.2–5.3	Okinawa Is.
15mm–48mm	9mm	1.7–5.3	Okinawa Is.
18mm–50mm	9mm	2.0–5.5	Okinawa Is.
20mm–48mm	9mm	2.2–5.3	Okinawa Is.
26mm–67mm	10mm	2.6–6.7	Okinawa Is.
90mm	13mm	6.9	Palao Is.
18mm	6mm	3	Palao Is.

Description. Disc small, swollen, rays long and narrow, nearly circular in cross section. The rays are generally unequal in length, so the ratio of R:r is variable as is shown in the above table. Rays variable in number, mostly six, frequently five and rarely four or seven. Comet not rarely found.

Body covered with a rather thick skin. Numerous small pointed spinelets scattered uniformly all over the surface. Aboral skeleton composed of numerous small plates, variable in size and form, forming roundish irregular meshes, containing 4 to 8 papulae in a mesh.

Just external to adambulacrals, without intervening papulae, there is a series of plates, the inferomarginals. No ventrolateral plates. Superomarginal plates located immediately above the inferomarginal plates. Intermarginal papular areas in a series, with a papula in an area, proximally sometimes two or three. The superomarginal series bends more or less upward near the arm base, making the intermarginal space. Intermarginal plates arranged in two or three short series, but in small specimens the plates are wanting.

Adambulacral plates wider than long and separated by an interval, two-thirds of their own length. The armature is composed of three spines arranged in a transverse row. Deep in furrow exists a short, slightly curved, compressed spinelet with a pointed tip. The tip of the spinelet reaches about the base of the second spinelet situated on the furrow margin. The second spinelet is stouter, longer, compressed and truncated at the tip. Separated by a little space from the second spinelet is found a short, slightly curved, bluntly pointed spinelet.

Madreporites inconspicuous, mostly two in number, rarely one or three.

Localities. Ogasawara, Ryukyu and Palao Islands and Toyama Bay.

Distribution. Widely distributed in the Indo-Pacific regions; Palao Islands to the Ryukyu and Ogasawara Islands and Toyama Bay in Japan.

Genus *Henricia* GRAY

Henricia: GRAY, 1840, p. 184; Fisher, 1911, p. 266 (with synonymy); HEDING, 1935, p. 16; ——, 1936, p. 7.

The genus seems to commonly occur in the Pacific, including very puzzling forms. It is very difficult to determine just how many of the forms hitherto recorded being real species. Fisher ('11) described in his "North Pacific Asteroidea" many forms, with detailed descriptions and excellent illustrations. Recently Heding ('35, '36) pointed out that Fisher's *sanguinolenta*-group is not the species, and proposed to divide *Henricia* into two subgenera, *Henricia* and *Spinohenricia*. Specimens from Japan studied by the present writer, included 18 forms and they generally belong to the subgenus, *Henricia*. Among them two forms, *reticulata* and *irregularis*, have some features of *Spinohenricia* in having rudimentary marginal and ventrolateral plates, but not exactly agree with Heding's diagnosis in other characteristics.

Henricia specimens from Japan will be roughly grouped in three, A-group having thick and closely imbricated meshed skeleton; marginal and ventrolateral plates well defined, forming three regular series; B-group having reticulated open meshed skeleton; marginal and ventrolateral plates in three series, but intermarginal and ventrolateral areas wider than in A-group; C-group having inconspicuous marginal plates and ventrolateral plates irregularly arranged or only those adjacent to adambulacral plates arranged in a series; skeleton open or close meshed. The following forms belong to A-group: *leviuscula, leviuscula spiculifera, reniossa, tohokuensis, regularis, exigua, densispina, saghaliensis, kinkasana, nipponica, tumida.* B-group includes the following forms; *pacifica, aspera, Ohsimai, Ohshimai* forma *acutispina* and *pachyderma.* The following two forms belong to C-group; *reticulata* and *irregularis.* Among these three groups there can be seen the following scala from A- to C-group; the aboral skeleton has a tendency to be open, showing a

reticular appearance, and the marginal and ventrolateral plates become inconspicuous and the intermarginal and ventrolateral areas become gradually wide.

Key to Japanese species of *Henricia*

a^1. Aboral skeleton generally imbricated in close meshwork; marginal and ventrolateral plates well defined, forming three regular series adjacent to adambulacral plates; paxillae usually in groups.

b^1. Intermarginal areas confined to small triangular spaces at arm base; no secondary ventrolateral plates; no intermarginal connecting plates; rays stout and long, gradually tapering.

c^1. Furrow spines single; adambulacral spines not numerous; paxillae with small spinelets, not fine or delicate.

d^1. R about 5 to 6r; paxillae with 20 to 35 spinelets; 1 to 5 papulae in an area; adambulacral spines 7 to 10 or more; furrow spines single. ..... ***leviuscula***

c^2. Furrow spines single, distally double; adambulacral spines numerous; paxillae with numerous fine delicate spinelets.

d^1. R about 5.5r; intermarginal areas variable in width; paxillae with 40 to 70 fine spinelets; 1 to 3 papulae in an area; adambulacral spines 25 to 40; aboral plates roundish, lunular and rod-like in form. ..... ***spiculifera***

d^2. R about 8r; paxillae with 40 to 60 fine spinelets; a single papula in an area; adambulacral spines 15 to 25; large reniformed aboral plates, uniform in size. ..... ***reniossa* n. sp.**

d^3. R 6 to 7r; paxillae with 30 to 50 fine spinelets; 1 to 5 papulae in an area; adambulacral spines about 15; large reniformed aborals and small rod-like ones. ..... ***tohokuensis* n. sp.**

b^2. Intermarginal areas not confined to small triangular spaces at arm base; no connecting intermarginal plates; aboral plates about uniform in size.

c^1. Intermarginal areas narrow and prolonged.

d^1. R 3.7r; rays rather slender, gradually tapering; paxillae with 9 to 20 small spinelets; a single papula in an area; adambulacral spines slender, 13 to 17; furrow spinelets single or double; aboral plates subquadrate, regularly arrranged in oblique transverse rows ..... ***regularis* n. sp.**

d^2. R 4.2 to 4.5r; rays slender, tapering; paxillae with 5 to 13 fine spinelets; 1 to 3 papulae in an area; adambulacral spines slender, 13 to 15; furrow spinelets double; aboral plates arranged irregularly. ..... ***exigua* n. sp.**

c^2. Intermarginal plates quite similar to superomarginals in size and form, not decreasing in size toward distally.

d^1. R 3.8 to 5.3r; rays relatively long, gradually tapering; paxillae with 30 or more spinelets; 1 to 3 papulae in an area; adam-

bulacral spines bluntly pointed, 11 to 16; furrow spinelets single, rarely double; subtriangular aboral plates... ***densispina***

d^2. R 3.7 to 4.9r; rays swollen, occasionally constricted at base; paxillae with 5 to 18 spinelets; 1 to 3 papulae in an area; adambulacral spines bluntly pointed, 10 to 12; furrow spinelets single, distally double; a rudimentary secondary series of ventrolateral plates at arm base. ..... ***saghaliensis* n. sp.**

b^3. Intermarginal and ventrolateral areas more or less spacious; secondary ventrolateral plates; intermaginal plates connected longitudinally by smaller plates.

c^1. R 2.5 to 4r; rays rather short gradually tapering; paxillae with 7 to 15 spinelets, a single papula in an area; adambulacral spines bluntly pointed, 6 to 9 (11). ..... ***nipponica***

c^2. R 3.8 to 4.7r; rays slender, tapering; paxillae with 5 to 18 delicate spinelets; a single papula in an area; adambulacral spines slender, 8 to 12; intermarginal and secondary ventrolateral series short..... ..... ***kinkasana* n. sp.**

c^3. R 2 to 3r; rays short; paxillae with 3 to 10 small spinelets; a single papula in an area; adambulacral spines 4 to 5..... ***tumida***

a^2. Aboral skeleton reticulated in open mesh work; marginal and ventrolateral plates in three series, but never conspicuous; intermarginal and ventrolateral areas wide; secondary ventrolateral plates and intermarginals well developed, connected longitudinally by small plates.

b^1. Intermarginal and ventrolateral areas relatively narrow; rays long and slender.

c^1. R 5.6 to 6.7r; paxillae with 5 to 10 small spinelets in groups; 1 to 5 papulae in an area; adambulacral spines 10 to 15; furrow spinelets single. ..... ***pacifica* n. sp.**

c^2. R about 5r; paxillae with 5 or 6 (4–10) small spinelets in groups or more or less in curved series, 1 to 6 papulae in an area; adambulacral spines 5 to 7; furrow spinelets single, distally double. ..... ***aspera***

b^2. Intermarginal and ventrolateral areas more wide; rays moderately long, gradually tapering.

c^1. R about 3.5 to 4.5r; paxillae with 4 to 15 small spinelets generally in curved series; 1 to 5 papulae in an area; adambulacral spines bluntly pointed, 5 to 8; furrow spinelets single, double at the very tip. ..... **Ohshimai**

c^2. R 4 to 5.2r; rays rather slender; paxillae with 3 to 7 smaller spinelets; 1 to 6 papulae in an area; adambulacral spines long and slender, 5 or 6; furrow spinelets single or double..... ..... ***acutispina* n. forma**

c^3. R 4.4 to 6r; intermarginal and ventrolateral areas much wide; body covered with a thick skin; rays occasionally constricted at base; paxillae with 5 to 10 spinelets in group; adambulacral spines thick, 5 or 6; furrow spines single. ..... ***pachyderma* n. sp.**

a^3. Marginal plates inconspicuous; intermarginal and ventrolateral area seemingly much wide; aboral skeleton open or close meshed.

b^1. R 4.2 to 4.5r; skeleton open meshed; a distinct series of ventrolateral plates adjacent to adambulacral plates; rays broad, gradually tapering; paxillae with 5 to 18 small spinelets; 2 to 6 papulae in an area; adambulacral spines bluntly pointed, 4 to 6; furrow spinelets single..... ..... ***reticulata* n. sp.**

b^2. R 6r; skeleton weak, close meshed; no regular series of aboral and ventrolateral plates; rays long, flexible; paxillae with 4 or 5 (2–9) minute spinelets; single papula in an area; adambulacral spines slender, 10 to 23; furrow spines double. ..... ***irregularis* n. sp.**

Henricia leviuscula (STIMPSON)

(Pl. 8, figs. 14, 15)

Henricia leviuscula: FISHER, 1911, p. 280, pl. 69, figs. 1, 2, pl. 70, figs. 1, 2, pl. 71, figs. 2, 3, pl. 111, fig. 6.

?*Henricia leviuscula*: UCHIDA, 1928, p. 791.

The present species is not represented in any collection obtained from Japanese waters. Two specimens examined were obtained from Kadiak, Alaska, one of which measuring 75–80 mm in R, 14 mm in r, and the other 60 mm in R, 10 mm in r.

Diagnosis. Rays five, relatively long and slender, gradually tapering, R about 5 to 6r (3 to 7r). Aboral pseudopaxillae closely set, showing a granuliform appearance, a little larger than papular areas, the spinelets being short, numerous. Adjacent to adambulacral plates three very regular series of juxtaposed plates; the superomarginal series bends abruptly upward at the arm base, while the inferomarginal one runs parallel to the ventrolateral series to the mouth angle, and a small triangular intermarginal area is thus formed between both the marginals, filled with a variable number of smaller plates. Adambulacral armature composed of 7 to 10 (8–12) stubby spines in two transverse series. Furrow spinelets single.

Description. Aboral paxillae closely set, larger than papular areas, the large paxillae each with 20 to 35 spinelets, showing a granuliform appearance. The spinelets are short, the tip being spiny, not bluntly pointed. Papular areas each with one to five pores. Aboral plates imbricated, swollen, roundish or elliptical in form, though sometimes irregular, those on the carinal region larger

than in the dorsolateral regions where they are arranged more or less in transverse rows, each corresponding to a superomarginal plate in position.

Marginal and ventrolateral plates, characteristic of the species, large, conspicuous and arranged in three regular longiseries. Superomarginal plates juxtaposed to the inferomarginals subequal to or a little smaller than the inferomarginals. The superomarginals abruptly bend upward at the interbrachial angle, while the inferomarginals run parallel to the furrow to the mouth angle. The intermarginal area is small, triangular in form, containing a

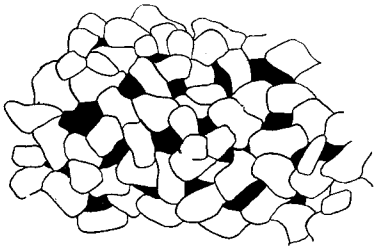


Fig. 1

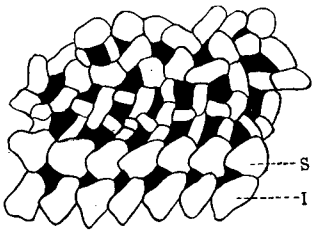


Fig. 2

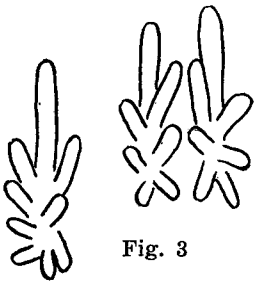


Fig. 3

Fig. 1. *Henricia leviuscula*; aboral plates in the middle portion of ray. 5×.

Fig. 2. *Henricia leviuscula*; marginal plates and adjacent aboral ones in the middle portion of ray. 5×. S, superomarginals; I, inferomarginals.

Fig. 3. *Henricia leviuscula*; adambulacral spines. 10×.

number of small plates. Ventrolateral plates much smaller than the marginals, arranged in a series, extending nearly to the tip. The ventrolaterals are opposited to the adambulacral plates in position, except the distal portion of ray, where the former is a little more numerous than the latter. Between these regular series are found series of papular areas usually with a papula in an area. The spinulation of these plates is similar to that of the aborals.

Adambulacral armature composed of seven to ten stubby spines arranged in two transverse rows, the inner one or two being longer and stouter than the outers. Furrow spines single, short and slender.

Madreporite circular, covered with spinelets identical with those of the adjacent aboral plates, situated nearer to the centre of disc than the margin.

Locality. Kadiak, Alaska.

Distribution. Aleutian Islands to Monterey Bay, California.

Remarks. Uchida ('28) describes the presence of the second row of ventrolateral plates in his *leviuscula* of Mutsu Bay as follows: "there is a small radial row between the peractinals and inferomarginals". In *leviuscula,* however, the ventrolaterals are to be in a distinct row. In Uchida's specimen, the adambulacral armature differs from the specimens obtained from Alaska in having more numerous spines and in peculiar arrangement of them. The writer is of the opinion that Uchida's specimen is not typical *leviuscula.* Such being the case, the occurrence of the species in Japanese waters has not been recorded.

Henricia leviuscula spiculifera (CLARK)

(Pl. 9, Figs. 3, 4.)

Cribrella spiculifera: CLARK, 1901, p. 328, pl. 2, pl. 4, fig. 1.
Henricia leviuscula multispina: FISHER, 1911, p. 286, pl. 72, figs. 1–4, pl. 73, figs. 1, 2; UCHIDA, 1928, p. 793, pl. 32, figs. 2, 3.
Henricia spiculifera: FISHER, 1911, p. 295.
Henricia leviuscula spiculifera: VERRILL, 1914, p. 222; FISHER, 1930, p. 195.

The present species has previously been reported in Japan from Shimushir, Kurile Islands, by Fisher, ('11) and from Mutsu Bay by Uchida ('28). The writer examined a single specimen of Albatross collection in 1906, which is referable to the species, though not being the typical form. It was obtained from East Cape, Attu Is., measuring 61 mm in R, 11 mm in r.

Diagnosis. Disc rather small, rays gradually tapering, R about 5.5r. Differing from *leviuscula*; in having paxillae showing an appearance of velety nap, with numerous delicate spinelets; papular areas being smaller; in adambulacral armature having numerous spinelets and two furrow spinelets deep in furrow in the distal half of ray.

Description. Aboral plates smaller, more numerous and more closely crowded than in *leviuscula,* consequently the papular areas

being smaller, containing one to three papulae in an area. The plates are imbricated, irregular rounded or more or less crescentic in form, and the dorsolateral plates are arranged in fairly regular transverse rows, each corresponding to a superomarginal plate. The spinelets grouped in pseudopaxillae are fine and delicate, longer than in *leviuscula,* very numerous, showing an appearance of velety nap, not granular as in *leviuscula,* numbering about 40 to 70 for a plate. They are glassy when dried, with very fine spiny tips. The spinulation of marginal and ventrolateral plates is similar to that of the aborals.

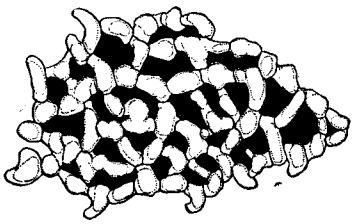


Fig. 4

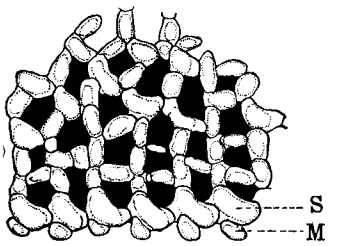


Fig. 5

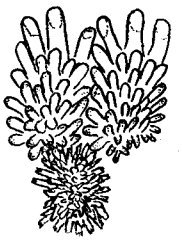


Fig. 6

Fig. 4. *Henricia leviuscula spiculifera*; aboral plates in the middle of ray. 7×.

Fig. 5. *Henricia leviuscula spiculifera*; dorsolateral plates. 7×. S, superomarginals; M, intermarginals.

Fig. 6. *Henricia leviuscula spiculifera*; adambulacrai spines and ventrolateral ones in the middle portion of ray. 10×.

Marginal and ventrolateral plates very distinct, forming three regular longiseries. The superomarginals bend upward proximally, while the inferomarginals run parallel to the ventrolaterals to mouth angle. The intermarginal areas, therefore, are not confined to a small triangular area at arm base, and more numerous small plates than in *leviuscula* are present. The intermarginal paxillae are in four or five longiseries at the arm base, but not very regular; those just below the superomarginals extending halfway along ray as a regular series; the second extending to one-third the length of ray. Ventrolateral plates reaching nearly the arm tip. Between these regular series of plate are found series of papular areas with mostly

a papula in an area. In the specimen examined, however, the second series of ventrolateral plates is found between the ventrolaterals and inferomarginals. It is rudimentary and composed of 2–4 small plates in a series at arm base.

Adambulacral spines very numerous, 25 to 40 in number, gradually increasing in size and length toward the furrow margin. They are arranged in four to six somewhat irregular transverse series on the outer part of plate, the inner three to four spines being stout and compressed; and the outer being similar to those of the ventrolaterals. Furrow spines single, but double (one above the other) on the outer half portion of ray.

Madreporite inconspicuous, covered with delicate spinelets similar to those of the adjacent plates, and situated about midway between the centre of disc and the margin.

Locality. East Cape, Attu Islands.

Distribution. From Oregon to Bering Sea, Bering Strait, the Aleutian, south to Shimushir, Kurile Islands.

Remarks. The specimen examined differs from Fisher's *multispina* in the intermarginal area, but according to Fisher ('11) the intermarginal plates seem to be variable in the species;" sometimes they are confined to a small triangular area at base of ray and sometimes extending halfway along ray as a regular series of small roundish pseudopaxillae; occasionally a second row is present extending or quite as far as the first". The writer's specimen seems to belong to the latter case, but the writer surmises that the specimen having such state of intermarginal plates is not the typical form of the species and it may be perhaps due to hybridism, local variation etc. The writer can not conclude here, whether the presence of a second series of ventrolateral plates in the specimen, though being rudimentary, is only an aberrant case in the species or not. Uchida's specimens are seemingly no typical form of the species; the spinulation is fewer and furrow spinelets single.

Henricia reniossa n. sp.

(Pl. 8, figs. 16, 17.)

The present species is so different from *leviuscula* that it may be told at a glance. The present writer, however, supposed that the

species belongs to *leviuscula*-group, judging from the skeletal structure of marginal and ventrolateral plates. It resembles *H. leviuscula spiculifera,* but distinctly differs from the latter in the ratio of R:r and in having characteristic prominent reniform aboral plates and spinulation and in adambulacral armature. It seems to be a new form of *Henricia,* having long rays and the characteristic structure of aboral skeleton. The measurements and localities are as follows:

R	r	R:r	Locality	Depth	Collection	Station
118–85mm	15mm	7.8	Bomasiri Sima	190fms	Albatross, 1906	4994–*Type*
128mm	15mm	8	Yezo Strait	86fms	Albatross, 1906	5031

Diagnosis. Rays five, long, R about 8r. Aboral skeleton closely meshed, composed of prominent reniformed plates, rather uniform in size. Papular areas small, each with a single papula, rarely double. Aboral paxillae with numerous fine, delicate spinelets, 40 to 60 or more. Three distinct regular series of plates adjacent to adambulacral plates; adambulacral spines numerous, 15 to 25; furrow spines mostly single, but double near the arm tip.

Description. Disc small, rays long, gradually tapering. Reniformed aboral plates large, uniform in size, enclosing the papular area on the concave side. Plates arranged more or less in longiseries on the dorsolateral portion of ray, and small rod-like plates dividing papular areas found here and there. Papular areas very small, each containing a single but rarely double papulae. Aborals uniformly covered with very fine, delicate, rough tipped spinelets, fewer and much finer than in *spiculifera,* numering about 40 to 60 or more on a plate.

Marginal and ventrolateral plates arranged in three regular series as in *leviuscula.* Inferomarginals larger than the superomarginals and elongated transversely, especially at arm base. Superomarginals larger than the dorsolateral plates, subquadrate or subtriangular in form. The superomarginal series bends abruptly upward at arm base, while the inferomarginal series runs parallel to the ventrolateral one to mouth angle, thence the intermarginal area is small, triangular in form. Intermarginal plates about same as large as the superomarginals just above, about ten in number. Ventrolateral plates generally opposite to each adambulacral plate in position, extending near the arm tip, but not to the very tip. Between these regular series of plates are found series of papular

areas with one or two papulae in an area. The spinulation of these plate is similar to that of general aboral plates.

Adambulacral plates armed with about 15 to 25 spines, gradually increasing in length and thickness toward the furrow, the inner five or six being long and stout, often compressed at the tip, while the

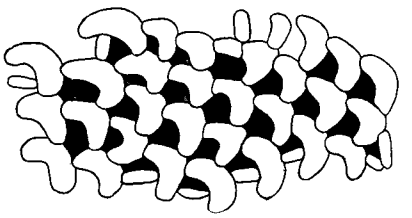


Fig. 7

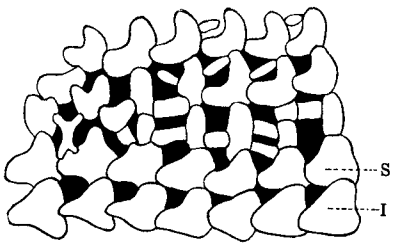


Fig. 8

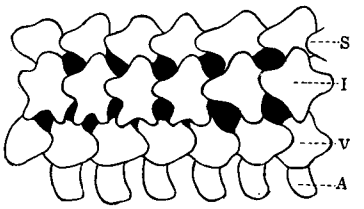


Fig. 9

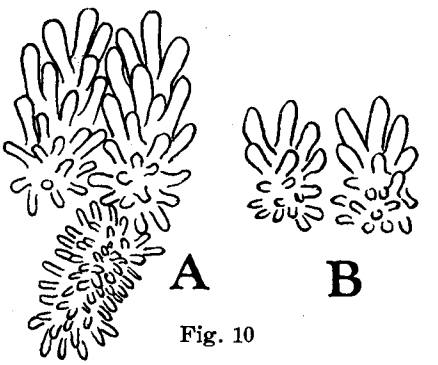


Fig. 10

Fig. 7. *Henricia reniossa* n. sp.; aboral plates in proximal dorsolateral portion of ray. 5×.

Fig. 8. *Henricia reniossa* n. sp.; dorsolateleral and marginal plates. 5×. S, superomarginals; I, inferomarginals.

Fig. 9. *Henricia reniossa* n. sp.; marginal, ventrolateral and adambulacral plates in proximal portion of ray. 5×. S, superomarginals; I, inferomarginals; V, ventrolaterals; A, adambulacrals.

Fig. 10. *Henricia reniossa* n. sp.; adambulacral spines; A in the proximal portion of ray, B in the middle. 10×.

outers being similar in size to those of ventrolateral plates. Furrow spines single, but double near the arm tip. Madreporite slightly convex, circular in form, covered with delicate spinelets similar to those of the aborals, situated nearer to the centre of disc than the margin.

Localities. Bomasiri Sima and Yezo Strait.

Henricia reniossa forma *tohokuensis* n. forma

(Pl. 7, figs. 11, 12.)

In general appearance the present species resembles the preceeding species, *H. reniossa,* but differs from the latter in the following characteristics: Aboral plates various in size and form, not so thick and not closely crowded, consequently papular areas being larger; aboral spinelets fewer and slightly coarser; adambulacral spines fewer, furrow spinelets double in the distal half of ray as in *spiculifera.* On the other hand, the species is related to *H. leviuscula* forma *dyscrita,* but remarkably differs from it in the ratio of R:r and in the furrow spines, those of *dyscrita* not being double on the outer half of ray. It may be a southern form of *reniossa.* Four specimens examined, the measurement and locality being as follows:

R	r	R:r	Locality	Depth	Collection	Station
95– 90mm	14mm	6.8–6.4	between Hatinohe and Kuji	200M	Sōyōmaru, 1926	66
100– 80mm	16mm	6.3–5	off Tobisima	200M	Sōyōmaru, 1930	610–*Type*
113– 98mm	15mm	7.5–6.5	off Hesasi	200M	Sōyōmaru, 1930	640
115–100mm	16mm	7.2–6.3	off Cape Oga	200M	Sōyōmaru, 1930	630

Diagnosis. Rays five, long, R about 6r to 7r. Differing from *H. reniossa,* in the skeletal structure of aboral plates and adambulacral armature and in having fewer and slightly coarser spinelets in paxillae.

Description. Aboral plates smaller than in *H. reniossa,* crescentic, rounded and rod-like in form. Papular areas larger than the plates, with 1 to 5 papulae in an area. Dorsolateral plates small, elongated, nearly uniform in size, forming relatively regular meshes.

Marginal and ventrolateral plates forming three regular longiseries as in *leviuscula,* but less conspicuous than in *leviuscula* and *reniossa.* Superomarginals much larger than the adjacent aborals and abruptly bending upward at the arm base, while inferomarginals running parallel to ventrolaterals, much wider than long, about twice as large as the superomarginals and ventrolaterals. Ventrolaterals longer than wide and smaller than the marginals. Intermarginal area small, triangular in form, the plates being small, about 20 or

more in number, arranged in 2 or 3 short rows. Between these regular series of plates are found series of papular areas with mostly a single papula in an area. Large aboral paxillae bearing about 25 delicate, fine spinelets, which are fewer and very slightly coarser than those of *reniossa*. The spinulation of these plates stated above is similar to that of the aborals.

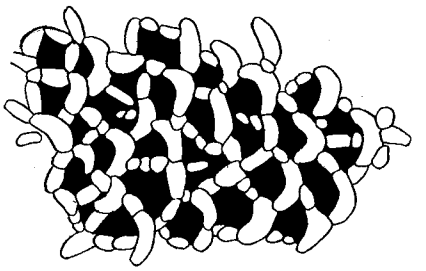


Fig. 11

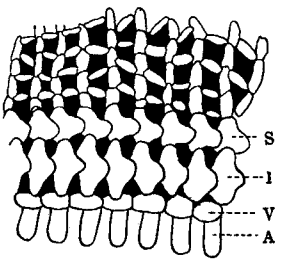


Fig. 12

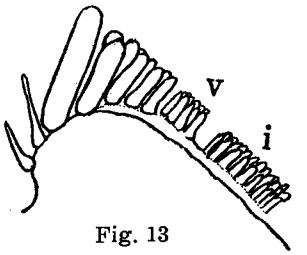


Fig. 13

Fig. 14

Fig. 11. *Henricia reniossa* forma *tohokuensis* n. forma; aboral plates in the proximal portion of ray. 5×.

Fig. 12. *Henricia reniossa* forma *tohokuensis* n. forma; marginal and ventrolateral and adambulacral plates. 5×. S, superomarginals; I, inferomarginals; V, ventrolaterals; A, adambulacrals.

Fig. 13. *Henricia reniossa* forma *tohokuensis* n. forma; adambulacral spines in the middle portion ray. 10×. v, ventrolateral spines; i, inferomarginals.

Fig. 14. *Henricia reniossa* forma *tohokuensis* n. forma; adambulacral spines in the middle portion of ray. 10×.

Adambulacral armature similar to that of *reniossa*, though being fewer. Adambulacral plates with about 15 spines as in *dyscrita*; the inner three or four being long and stout, and the outers similar to the ventrolateral spinelets, arranged more or less in three transverse rows. Furrow spines double on the distal half portion of ray, but single proximally.

Madreporite covered with spinules like those of the adjacent aborals, situated about midway between the centre of disc and the margin.

Localities. Between Hatinohe and Kuji, off Tobisima, off Hesasi and off Cape Oga.

Henricia regularis n. sp.

(Pl. 10, figs. 3, 4.)

The present species is related to *H. densispina*, but differs in the aboral and marginal sketeton. The spinulation is finer than in *densispina* and the adambulacral plates have much slender numerous spines, not bluntly pointed or nearly uniform as in *densispina*. The measurements and localities are as follows:

R	r	R:r	Depth	Nature of bottom	Locality	Collection	Station
15mm	4mm	3.7	41 fms	sand & shells	Uraga	Goto	
30mm	8mm	3.7	200 M		off Goto Is.	Sōyōmaru	440

Diagnosis. Rays five, rather slender, gradually tapering. R being 3.7 r. Pseudopaxillae in distinct groups, with 9–20 small spineletes. Aboral skeleton composed of subquadrate plates thickly imbricated, uniform in size. Papular areas small, with a single papula in an area. Three regular series of plates external to adambulacral plates. Adambulacral spinelets, 13–17, arranged in irregular transverse rows, and furrow spinelets single or double.

Description. Aboral plates large, generally uniform in size and subquadrate in form, arranged in rather regular oblique transverse rows. Those on the lateral portion of ray are not smaller than the carinals. The paxillae composed of small delicate 10–12 spinelets distinctly grouped. Papular areas small, usually containing a single papula in an area.

Marginal and ventrolateral plates conspicuous, not much compressed and arranged in three regular series. Superomarginals about same as large as the adjacent aborals and a little smaller than the inferomarginals. The superomarginals gradually diverge, not abruptly near the base of ray, while the inferomarginals run parallel to the mouth angle, each with 25 to 30 small spinelets similar to the aborals. Intermarginals same as large as the superomarginals, extending halfway along ray as a series. Ventrolaterals in a single

series reaching nearly the tip of ray, each with 18–22 small spinelets. Between these regular series of plates are found series of papular areas, each with a papula.

Adambulacral armature composed of 13–17 slender spinelets, arranged more or less in irregular three or four transverse rows. Furrow spines single, but mostly double in the distal portion of ray.

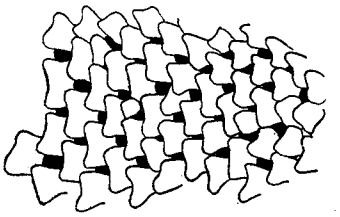


Fig. 15

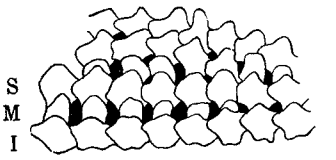


Fig. 16

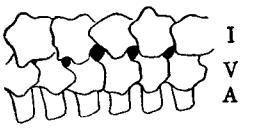


Fig. 17

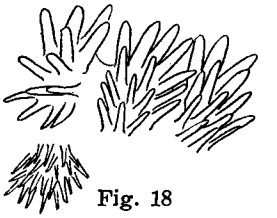


Fig. 18

Fig. 15. *Henricia regularis* n. sp.; aboral plates in the middle portion of ray. 7×.

Fig. 16. *Henricia regularis* n. sp.; marginal and dorsolateral plates in the middle portion of ray. 7×. S, superomarginals; I, inferomarginals; M, intermarginals.

Fig. 17. *Henricia regularis* n. sp.; inferomarginals (I), ventrolaterals (V) and adambulacrals (A) in the proximal portion of ray. 7×.

Fig. 18. *Henricia regularis* n. sp.; adambulacral spines in the proximal portion of ray. 15×.

Madreporite situated midway between the centre of disc and the margin, covered with spinules similar to those of adjacent aborals.

Localities. Uraga and off Goto Islands.

Henricia exigua n. sp.

(Pl. 7, figs. 5, 6)

The writer examined two small specimens closely resembling *Henricia kinkasana* n. sp. They, however, differ from the species

in the possession of well developed intermarginal plates; in the lack of secondary ventrolateral plates; and in the present of more numerous adambulacral spines and double furrow spines. The measurements and localities are as follows:

R	r	R:r	Locality	Depth	Collection	Station
21mm	5 mm	4.2	off Ise Bay	200 M	Sōyōmaru	370–*Type*
16mm	3.5mm	4.5	off Goto Is.	193 fms	Albatross, 1906	4902

Diagnosis. Rays five, slender, R ranging from 4.2 to 4.5r. Aboral skeleton closely meshed; papular areas small, containing 1 to 3 papulae; paxillae with 5 to 13 fine spinelets. Three regular

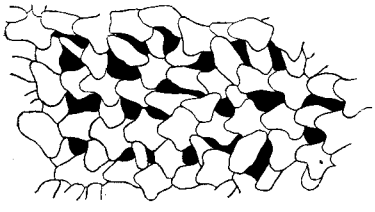


Fig. 19

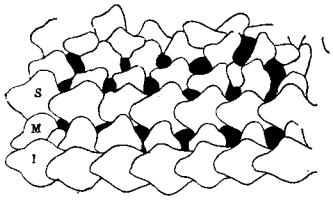


Fig. 20

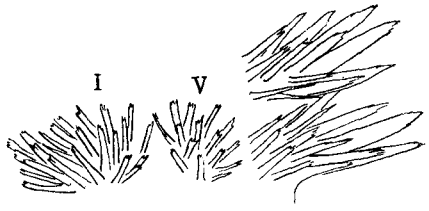


Fig. 21

Fig. 19. *Henricia exigua* n. sp.; aboral plates in the proximal portion of ray. 13×.

Fig. 20. *Henricia exigua* n. sp.; marginal plates in the middle portion of ray. 13×. S, superomarginals; I, inferomarginals; M, intermarginals.

Fig. 21. *Henricia exigua* n. sp.; adambulacral spines in the proximal portion of rays. 20×. V, ventrolateral paxilla; I, inferomarginal paxilla.

series of plates adjacent to adambulacral plates; a series of intermarginal plates extending to two-third the length of ray; ventrolaterals reaching nearly the tip. Adambulacral armature composed of 13–15 slender spinelets; furrow spinelets double.

Description. Disc small, rays very slender. Aboral skeleton closely crowded, similar to that of *kinkasana* n. sp.; paxillae each with 5 to 13 fine spinelets. Papular areas small, containing 1 to 3 papulae in an area.

Marginal plates well defined, forming three regular series with ventrolateral plates. Superomarginal plates very gradually bending upward, while inferomarginals running parallel to the furrow.

Intermarginal area narrow and prolonged, the plates reaching about two-third the length of ray as a series, and proximally adjacent to inferomarginals, the secondary series interpolated. Inferomarginal plates a little larger than the superomarginals, covered with delicate spinelets similar to aboral ones, about 20 or more in number. Ventrolateral plates arranged in a distinct series, reaching nearly the tip, each with about 15 spinelets. Between these regular series of plates are found series of papular areas, each with mostly a single pore.

Adambulacral armature composed of 13 to 15 spines, the 3 or 4 inner being larger than the outers which are short and slender. Furrow spines generally double in a vertical series.

Madreporite small, circular, covered with spinules similar to the adjacent aborals, situated about midway between the centre of disc and the margin.

Localities. Off Ise Bay and off Goto Islands.

Henricia densispina SLADEN

(Pl. 10, figs. 7, 8.)

Henricia densispina: SLADEN, 1879, p. 432, pl. 8, figs. 5–9.
?*Henricia leviuscula*: UCHIDA, 1928, p. 791.

The writer examined two specimens in Goto's collection, probably referable to *Hericia densispina* Sladen, one of which was obtained from Aomori Bay; the other with no label of locality. The specimen of Aomori Bay measures 23 mm in R, 5.5 mm in r. The species resembles more or less *Henricia leviuscula* and much *spiculifera,* but differs from them in the skeletal structure of aboral and marginal plates and in the adambulacral armature. The spinelets are coarser than in *spiculifera* and finer than in *leviuscula.*

Since Sladen's report on the species from Korean Strait, *densispina* was recorded by Fisher ('19) from the Philippines. Specimens examined by the writer closely agree with Sladen's original description, rather than Fisher's description. Uchida's *H. leviuscula* of Mutsu Bay may be probably a form of the present species.

Diagnosis. Rays five, relatively long and slender, with obtuse tips. R about 3.8 to 3.5r. Aboral paxillae closely crowded, with numerous spinelets; papular areas each with 1 to 3 papulae. Three

regular series of plates adjacent to adambulacral plates; superomarginals showing a peculiar arrangement in the proximal portion of ray. Adambulacral spines 11 to 16 in two or three rows; furrow spines single, rarely double.

Description. Aboral paxillae densely crowded, with numerous spinelets, about 30 or more, uniform in size, showing a granular appearance. Papular areas small, each containing 1 to 3 pores, occasionally 5 in large ones. Aboral plates closely meshed, composed of subtriangular plates, about uniform in size.

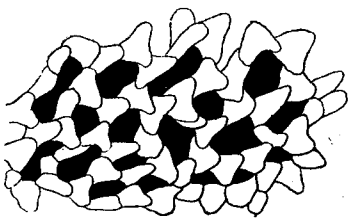


Fig. 22

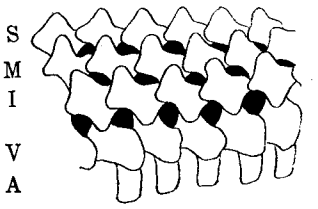


Fig. 23

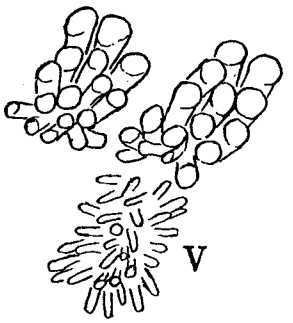


Fig. 24

Fig. 22. *Henricia densispina*; aboral plates in the middle of rays. 7×.

Fig. 23. *Henricia densispina*; marginal, ventrolateral and adambulacral plates in the proximal portion of ray. 7×. S, superomarginals; I, inferomarginals; M, intermarginals; V, ventrolaterals; A, adambulacrals.

Fig. 24. *Henricia densispina*; adambulacral spines in the proximal portion of ray. 25×. V, ventrolateral paxilla.

Marginal plates well defined, as in *leviuscula*, forming three regular series of plates with ventrolaterals. Inferomarginal plates transversely elongated, each with about 50 or more spinelets similar to those of aboral plates. In the proximal portion of ray there are three series of plates just above the inferomarginal series; plates being exactly similar in size and form, not evidently larger than the adjacent aborals, each with 40 or more spinelets. These series of plates are connected in the manner of stairs with the superomarginal series in the middle portion of ray; in some rays the uppermost series seems to be the representative of superomarginals, but

in others the lowermost one seems to indicate the series. If the uppermost series is admitted as superomarginals, it is to be noted that the intermarginals are arranged in two regular series, quite similar to the superomarginals in size and form, one of the intermarginals extending to two-third the length of ray and the other to one-fourth the length of ray. Ventrolateral plates in a series, reaching the tip, each opposite to adambulacral plates and inferomarginal plates, each with 30 to 40 spinelets similar to those of marginals. Between these regular series of plates are found series of papular areas, mostly with a papula in an area.

Adambulacral armature composed of 11 to 16 bluntly pointed spines, arranged in two or three transverse rows, the two or three inner being larger than the outers which are nearly uniform in size. Furrow spines short and small, generally single, rarely double. In the small specimen the adambulacral spines fewer, about ten spines arranged in two transverse rows, quite similar to the figure of Sladen.

Madreporite covered with spinelets similar to those of adjacent plates, situated about midway between the middle of disc and the centre.

Locality. Aomori Bay.

Distribution. Known from Korean Strait and Aomori Bay.

Henricia saghaliensis n. sp.

(Pl. 7, figs. 3, 4.)

The present species shows an appearance of *pachyderma* n. sp. in the form of body, but differs from it in the structure of skeleton and the spinulation, and moreover, the whole body is not so densely covered with a thick integment as in *pachyderma*. On the other hand, they are more or less related to the description of *Henricia sanguinolenta* by Fisher, but are different from the species in the body form and in having broad and prominent marginal plates.

The measurements and localities are as follows:

R	r	R:r	Locality	Depth	Collection	Station
59mm	12mm	4.9	Cape Patience, Saghalin	75 fms	Albatross, 1906	5032
55mm	15mm	3.7	„	„	„	„ *–Type*
46mm	10mm	4.6	„	„	„	„

Diagnosis. Rays five, thick and broad, constricted at base. R ranging from 3.7 to 4.9r. Aboral plates nearly uniform, forming irregular reticulation. Papular areas rather small, various in form. Marginal plates distinct. Intermarginal area narrow. Ventrolateral plates extending the arm tip and the second series present. Adambulacral armature composed of 10 to 12 bluntly pointed spines; furrow spinelets single, distally occasionally double.

Description. Disc rather small, rays thick and broad, constricted at base or gradually tapering. Aboral skeleton composed of comparatively large imbricated plates, nearly uniform in size. Papular areas rather small, various in form, each with 1 to 5 (mostly 1 to 3) papulae. Aboral paxillae each with 5 to 18 spinelets in group.

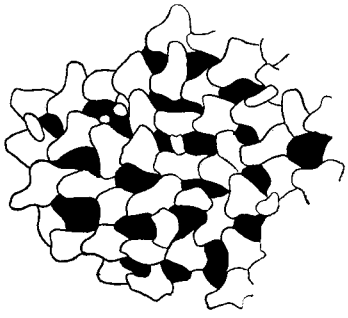


Fig. 25

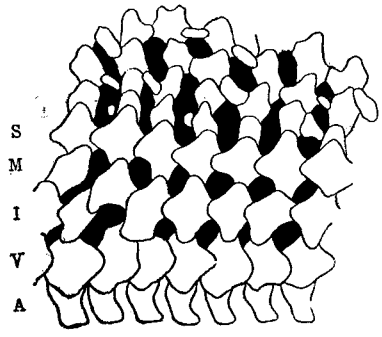


Fig. 26

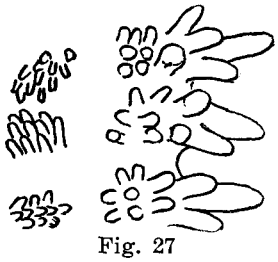


Fig. 27

Fig. 25. *Henricia saghaliensis* n. sp.; aboral plates in the proximal portion of ray. 5×.

Fig. 26. *Henricia saghaliensis* n. sp.; marginal, ventrolateral and adambulacral in the proximal portion of ray. 5×. S, superomarginals; I, inferomarginals; M, intermarginals; V, ventrolaterals; A, adambulacrals.

Fig. 27. *Henricia saghaliensis* n. sp.; adambulacral spines in the proximal portion of ray. 10×.

Marginal plates distinct as in *leviuscula*. Superomarginal plates, opposite to each inferomarginal plate, bending upward at arm base, but never abruptly as in *leviuscula*. Intermarginal area not wide. Intermarginal plates forming a short series exactly similar to the adjacent superomarginals in size and form as in *densispina*. Inferomarginal paxillae transversely elongated, with 20

to 25 spinelets in three irregular transverse rows, a little larger than the superomarginals. Ventrolateral plates extending near the tip; at the arm base a short series of the secondary plates present. Paxillae bearing each 8 to 15 small spinelets similar to marginal ones. Between these regular series of plates are found series of papular areas, each containing mostly a single pore.

Adambulacral armature composed of 10 to 12 bluntly pointed spines, the three inner being larger than the outers; the innermost one is the largest. They are arranged in two or three irregular transverse rows. Furrow spinelets single, but in the distal half of ray occasionally double.

Madreporite covered with spinules similar to the adjacent ones, situated about midway between the centre of disc and the margin.

Locality. Cape Patience, Saghalin.

Henricia kinkasana n. sp.

(Pl. 7, figs. 7, 8.)

The writer examined small, slender-rayed specimens which are probably adult, for some of them have a depression under the mouth, the remnant of brood pouch formed by arching of disc. They differ from other small, short-rayed *Henricia, nipponica* and *tumida,* in the skeletal structure and the mode of spinulation and other characteristics. It is probably a new form of *Henricia.* The measurements and locality are as follows:

R	r	R:r	Locality	Depth	Collection	Station
18mm	4.5mm	4	off Kinakasan	182 fms	Albatross, 1906	5049
20mm	5mm	4	,,	,,	,,	,,
20mm	5mm	4	,,	,,	,,	,,
20mm	5mm	4	,,	,,	,,	,,
19mm	5mm	4	,,	,,	,,	,,
21mm	4.5mm	3.8	,,	,,	,,	,,–Type
22mm	5mm	4.4	,,	,,	,,	,,
22mm	5mm	4.4	,,	,,	,,	,,
22mm	5mm	4.4	,,	,,	,,	,,
24mm	5mm	4.8	,,	,,	,,	,,
26mm	5.5mm	4.7	,,	,,	,,	,,

Diagnosis. Disc relatively small, rays five, long and slender, R ranging 3.8r to 4.7r. Aboral skeleton closely meshed, composed of

crescentic plates, rather uniform in size. Aboral paxillae each with about 5 to 18 delicate spinelets; papulae single. Adjacent to adambulacral plates three regular series of plates are present; marginal plates bending upward at interbrachial angle; intermarginal and secondary ventrolateral plates poorly developed. Adambulacral spinelets in two transverse rows, slender, 8 to 12 in number; furrow spinelets single.

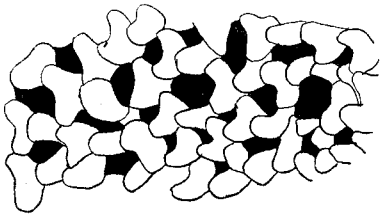


Fig. 28

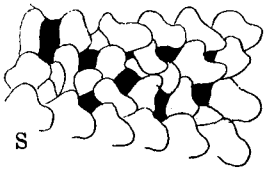


Fig. 29

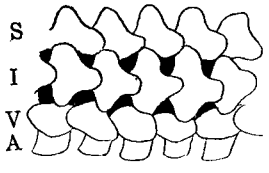


Fig. 30

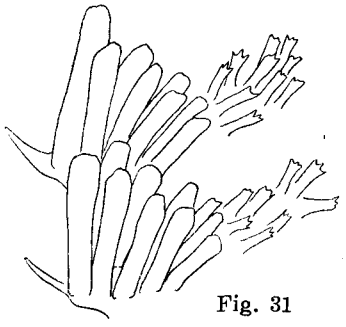


Fig. 31

Fig. 28. *Henricia kinkasana* n. sp.; aboral plates in the proximal portion of ray. 17×.

Fig. 29. *Henricia kinkasana* n. sp.; dorsolateral p'ates in the proximal portion of ray. 17×. S, superomarginal plates.

Fig. 30. *Henricia kinkasana* n. sp.; marginal, ventrolateral and adambulacral plates in the proximal portion of ray. 17×. S, superomarginals; I, inferomarginals; V, ventrolaterals; A, adambulacrals.

Fig. 31. *Henricia kinkasana* n. sp.; adambulacral spines in the proximal portion of rays. 40×.

Description. Aboral skeleton forming a closed irregular meshwork, composed of small reniform plates, rather uniform in size. Aboral plates covered with very fine delicate, rather long spinelets, about 5 to 18 for a paxilla. Papular areas small, usually with a single papula in an area.

Marginal and ventrolateral plates forming three regular series, but never so prominent as in *leviuscula*. Superomarginal and inferomarginal plates running parallel to the furrow and a little diverging at the arm base, bending more or less abruptly upward. Superomarginal plates about same as large as the adjacent aborals or only slightly larger than these plates. Inferomarginals a little larger than the superomarginals, bearing 7 to 18 delicate spinelets similar to those of the aborals. Intermarginal plates poorly developed, composed of two or three small plates in a series. Ventrolateral plates well developed, reaching nearly the arm tip, and at the arm base the second row of several plates is interpolated between the inferomarginal and the ventrolateral rows. Ventrolateral plates each with 6 to 10 delicate spinelets like those of the marginals. Between these three regular series of plates are found series of papular areas, with a papula in an area.

Adambulacral plates armed with 8–12 delicate graded spinelets arranged more or less in two transverse rows. Furrow spines slender, usually single.

Madreporite situated about midway between the centre of disc and the margin, covered with spinules similar to the adjacent aborals.

Locality. Off Kinkasan.

Henricia nipponica UCHIDA

(Pl. 8, figs. 1, 2, 3, 4.)

Henricia leviuscula var. *nipponica*: UCHIDA, 1928, p. 794, pl. 32, figs. 6, 7.

The present species was reported by Uchida ('28) from Mutsu Bay as a variety of *Henricia leviuscula*. It seems to be a rather common sea-star on shore in the northern part of Japan. They live on reef on shore near the low tide mark. The colour in life is variable; red, brick red, brown or dark brown. The species, though related to *H. tumida* found in Akkeshi, differs from the latter in having slender rays and in adambulacral armature. Superomarginal plates gradually bending upward, never abruptly in *leviuscula*; the intermarginal plates well developed, extending the middle of ray as a series; and secondary ventrolateral plates present. Judging from these characteristics the writer doubts whether *nipponica* belongs to *leviuscula* or not. He is of the opinion that Uchida's *nipponica*

is to be regarded as a distinct species, rather than as a variety of *leviuscula*. More than one hundred specimens were examined, some of the measurements being as follows:

R	r	R:r	Locality
10mm	3.5mm	2.9	Osyoro
10mm	4 mm	2.5	Osyoro
12mm	4 mm	3	Osyoro
12mm	4 mm	3	Inubosaki
14mm	5 mm	2.8	Hakodate
14mm	5 mm	2.8	Osyoro
20mm	6 mm	3.3	Akkesi
20mm	6 mm	3.3	Onagawa
20mm	5.5mm	3.6	Hakodate
23mm	6 mm	3.8	Osyoro
35mm	10 mm	3.5	Akkesi

The largest specimen measures 35 mm in R and 10 mm in r, but generally R being about 20 mm, the ratio of R ranging from 2.5 to 4r.

Diagnosis. Rays five, short and slender, gradually tapering, R generally about 20 mm. Aboral paxillae closely crowded, papular areas small, with a papula; aboral plates small, imbricating. Three regular series of plates; superomarginals gradually bending upward; a series of intermarginal plates extends to the middle of ray; secondary ventrolateral plates present. Adambulacral plates with 6–9 spines, more numerous in large specimens, arranged in two transverse series; furrow spinelets usually single.

Description. Aboral paxillae densely crowded, each bearing about 7 to 15 or more, rough tipped spinelets. Papular areas small, with a single papula in an area. Aboral plates small, unequal in size, roundish, rod-like or a little lunular in form.

Marginal and ventrolateral plates well defined, arranged in three regular series. Inferomarginals transversely elongated, a little larger than the superomarginals, each with about 10 to 15 spinelets (20 to 30 in large specimen), the latter with 7 to 12 spinelets (15 to 25 in large specimens). Superomarginals gradually bending upward from the middle of ray, not abruptly at the arm base as in *leviuscula*. Intermarginal plates a little smaller than the adjacent superomarginals, rod-like in form, reaching about the middle of ray as a series. Ventrolateral plates with 6 to 8 spinelets (12 to 15 in large specimen), reaching nearly the tip. With growth the secondary short series of

the plates becomes to occur at arm base, and the intermarginal plates have a tendency to be longitudinally connected with each other by small rod-like plates.

Adambulacral plates armed with 6 to 9 spines arranged in two transverse series or sometimes more or less in a zigzag series, three of them near the furrow being larger than the others. With growth,

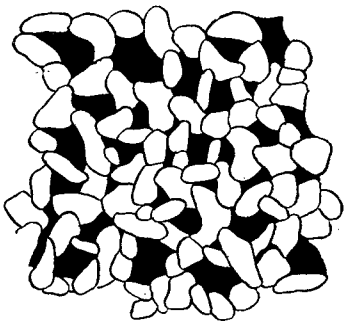


Fig. 32

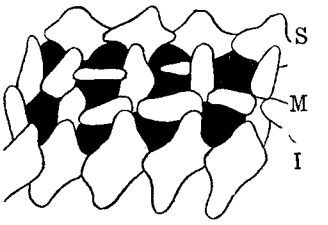


Fig. 33

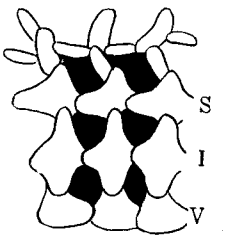


Fig. 34

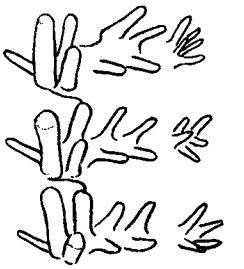


Fig. 35

Fig. 32. *Henricia nipponica*; aboral plates in the proximal portion of ray. 17×.

Fig. 33. *Henricia nipponica*; marginal plates in the proximal portion of ray. 17×. S, superomarginals; M, intermarginals; I, inferomarginals.

Fig. 34. *Henricia nipponica*; marginal and ventrolateral plates in the distal portion of ray. 17×. S, superomarginals; I, inferomarginals; V, ventrolaterals.

Fig. 35. *Henricia nipponica*; adambulacral spines and ventrolateral ones. 17×.

the spines increase in number; 10 to 13 spinelets (9–10 distally) arranged in two transverse rows in Akkesi specimens (R 35 mm).

Madreporite with spinules on the ridges, circular in form, situated about midway between the centre of disc and the margin.

Variations. In Akkesi specimens the ventrolateral secondary plates are absent, but in young specimens there is no way to distinguish them from specimens obtained from other localities. In Inubozaki specimens the ventrolaterals are poorly developed and aboral plates slightly larger and adambulacral spines a little more numerous than in other specimens similar in size, but there are no remarkable differences between these specimens, enough to distinguish from each other.

Localities. Osyoro, Hakodate, Muroran, Akkesi, Onagawa, Wakura and Inubozaki.

Distribution. Northern part of Japan.

Henricia tumida VERRILL

(Pl. 8, figs. 5–13)

Henricia tumida: VERRILL, 1909, pp. 554, 555, fig. 5; ——, 1914, p. 234, pl. 12, figs. 1, 2.
Henricia sanguinolenta eschrichtii: FISHER, 1911, p. 276, pl. 67, figs. 1–3, pl. 68, figs. 1, 2.
Henricia tumida borealis: VERRILL, 1914, p. 236, pl. 12, figs, 3, 4.
Henricia sanguinolenta forma *tumida*: FISHER, 1930, p. 194.

The writer examined a large number of short rayed *Henricia* in Akkesi, which are referable to an aberrant form of *tumida.* On the other hand, he examined ten short-rayed Alabatross' specimens obtained from Unalaska on shore (without station in label). They are probably the typical form of the species. It contains 8 female and 2 male examples. In female the disc shows more or less arching, some of them carrying youngs in the brood pouch, but in male the oral region is flat, not sunken. There are no remarkable differences between the specimens of Akkesi and Unalaska, but Akkesi specimens differ from the latter in having smaller paxillae with fewer and a little smaller spinelets; marginal plates less conspicuous; more developed ventrolateral plates. These specimens are probably an Asiatic form of the species.

The present species has been recorded by Fisher ('11) in Japan from Shimushir, Kurile Islands under the name of *H. sanguinolenta eschrichtii.* Concerning Pacific *eschrichtii* (*sanguinolenta* forma *tumida* of Fisher, '30), recently Heding ('35) gives an important discussion; "Probably Fisher's specimens may be regarded as a

variety of *eschrichtii*". The writer's specimens, however, distinctly differ from Atlantic *sanguinolenta* and *eschrichtii* of Heding, so the writer supposed that they are probably to be regarded as a distinct species, rather than a forma of these species.

In Akkesi they live on shore. The colour in life is dark yellow with small brown patterns and the anal aperture is usually blackish brown.

In the breeding season, from March to April in Akkesi, they brood their eggs or youngs in the brood pouch under the mouth, formed by arching of the disc and bringing the base of rays together. In 11 specimens examined, 57 to 143 youngs are found in a pouch. The youngs adhere with each other by an appendage of yolk substance. The appendage is absorbed by the young itself with growth. When the youngs are furnished with 6–7 pairs of tub-feet for a ray, they become free from the mother, then the mother gradually return to the normal condition. The measurements of the specimens taken at random are as follows:

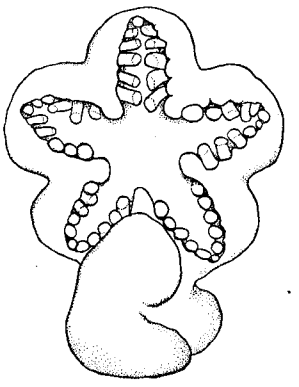


Fig. 36. *Henricia tumida*; young specimen. 20×.

R	r	R:r
6mm	3mm	2
11mm	4mm	2.7
14mm	5mm	2.8
15mm	5mm	3
18mm	6mm	3
20mm	6mm	3.3
23mm	7mm	3.3
28mm	8mm	3.5
30mm	11mm	2.7

Diagnosis. Rays five, short, R about 2 to 3r. Aboral paxillae closely crowded, each with 3 to 10 small spinelets; aboral plates small, various in form; papulae single; three regular series of plates external of adambulacral plates; intermarginal plates reaching the middle of ray; secondary ventrolateral plates; primary ventrolaterals extending nearly to the tip, with 1–3 spinelets; adambulacral armature composed of 4 to 5 spines in a transverse or zigzag series; furrow spines single.

Description. Disc moderately large, rays short, five in number, rarely four. Aboral plates small, closely crowded, papular areas small, mostly a single papula in an area. Aboral paxillae small, with 3–10 spinules.

There are three regular series of plates external of adambulacral plates, the middle series being the largest. In small specimens the superomarginal series more or less bends abruptly upward at the arm base, while the inferomarginal runs parallel to the furrow as

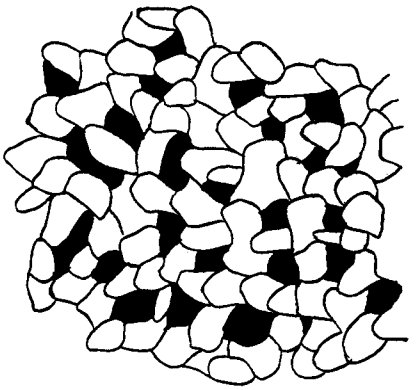


Fig. 37

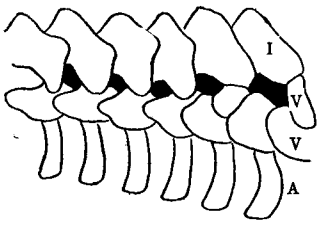


Fig. 38

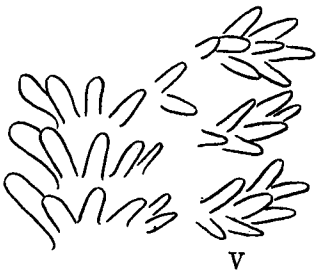


Fig. 39

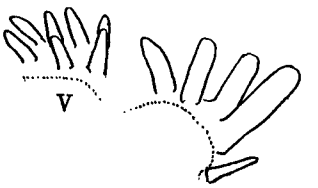


Fig. 40

Fig. 37. *Henricia tumida*; aboral plates in the proximal portion of ray. 17×.

Fig. 38. *Henricia tumida*; inferomarginal and ventrolateral plates in the proximal portion of ray. 12×. I, inferomarginals; V, ventrolaterals; A, adambulacrals.

Fig. 39. *Henricia tumida*; adambulacral spines in the proximal portion of ray. 17×. V, ventrolateral spines.

Fig. 40. *Henricia tumida*; side view of adambulacral spines in the middle of ray. 17×. V, ventrolateral spines.

in *leviuscula*. With growth the bending of superomarginal series becomes rather gradually, along with the development of intermarginal plates, and also the inferomarginal series bends a little upward by interpolating of second series of ventrolateral plates just

below the series. Inferomarginal plates about twice as large as the superomarginal, bearing 6–9 spinelets somewhat in two transverse rows. Superomarginals larger than the adjacent aborals, the paxillae with 5–7 spinelets. These spinelets are a little longer and stouter than the aboral ones. Intermarginal plates a little smaller than or same as large as the superomarginals, reaching about middle of ray. Ventrolateral plates extending near the tip of ray, with 1–3 spinelets, and in large examples the secondary series of the plates is found at the arm base, though being short. Between these regular series of plates are found series of papular areas with a single papula in an area.

Adambulacral armature composed of 4 to 5 bluntly pointed spines, gradually increasing toward furrow, the outer ones being similar to those of ventrolateral plates. They are arranged in a transverse series, occasionally in a zigzag series at the proximal portion of ray. Furrow spines usually single.

Madreporite with spinules on the ridges, circular in form, situated about midway between the centre of disc and the margin.

Locality. Akkesi.

Distribution. Arctic Ocean, north of Bering Strait; westward along Alaskan Peninsula and Aleutian Islands to Bering Island and Kamchatka, to Sea of Okhotsk, and south to Shimushir, Kurile Islands and Akkesi.

Henricia pacifica n. sp.

(Pl. 9, figs. 7–10.)

?*Henricia leviuscula* var. *inequalis*: UCHIDA, 1928, p. 792, Pl. 32, figs. 4, 5.

The present species indicate an intermediate form between *H. arcystata* in the Philippines and *H. clarki* in the north Pacific. From *arcystata* it differs in having more numerous adambulacral spines and a single furrow spine, not three in a vertical series, and from *clarki* differs in having much fewer adambulacral spines and a single furrow spine, and the tendency to make secondary mesh in a primary aboral mesh is not conspicuous. The species differs from *H. aspera* in having more complex adambulacral armature, more flexible rays and weaker skeleton. Judging from the description, *Henricia leviuscula* var. *inequalis* reported by Uchida ('28) from Mutsu Bay (not

Verrill's *inequalis=leviuscula* of Fisher) is probably referable to the species. The measurements are as follows:

R	r	R:r	Locality	Depth	Collection	Station
44mm	7mm	6.2	off Goto Is.	200M	Sōyōmaru	655
45mm	8mm	5.6	Tugaru Strait	200M	Sōyōmaru	444–*Type*
74mm	11mm	6.7	off Seto	200M	Sōyōmaru	211

Diagnosis. Rays five, long and slender, flexible. R ranging from 5.6 to 6.7r. Aboral skeleton small, closely crowded, forming

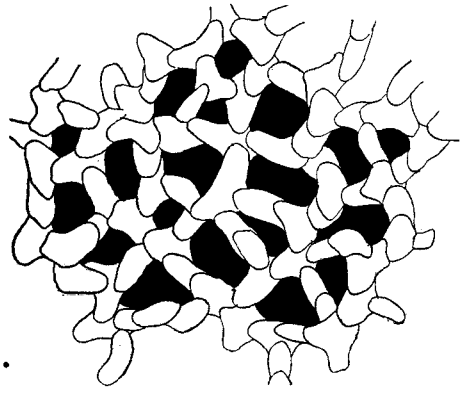


Fig. 41

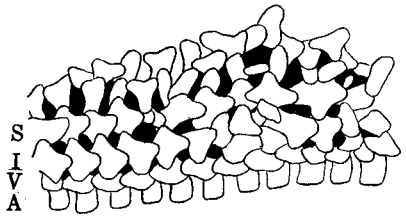


Fig. 42

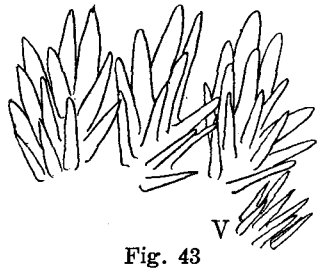


Fig. 43

Fig. 40. *Henricia pacifica* n. sp.; aboral plates in the proximal portion of ray. 12×.

Fig. 42. *Henricia pacifica* n. sp.; ventrolateral skeleton in the middle portion of ray. 7×. S, superomarginals; I, inferomarginals; V, ventrolaterals; A, adambulacrals.

Fig. 43. *Henricia pacifica* n. sp.; adambulacral spines in the proximal portion of ray. 20×. v, ventrolateral spines.

irregular sinuous mesh work. Papular areas small, with mostly 1 to 5 papulae. Paxillae small closely crowded, with 5 to 10 small spinelets. Marginal plates relatively inconspicuous, especially in superomarginals. Adambulacral plates armed with 10 to 15 slender spinelets; furrow spinelets single, long and slender.

Description. Aboral plates small, reticulating in irregular meshwork, but some of the meshes contain small ossicles subdividing papular areas. Papular areas small, irregular in form, with 1 to

5 papulae in an area, according to size of areas. Aboral paxillae densely crowded, small, each with 5 to 10 small pointed spinelets.

Marginal plates relatively indistinct; superomarginal paxillae hardly distinguishable from the adjacent aborals. When denuded, superomarginals very gradually bending upward from the middle portion of ray, opposing to inferomarginals. Inferomarginal plates much larger than superomarginals, transversely elongated, each bearing about 10–15 spinelets. Intermarginal area prolonged, the plates reaching about two-third the length of ray and in the proximal half of ray, and longitudinally connected with each other by smaller rod-like plates, where two series of papular areas are found.

Ventrolateral plates extending three-fourth the length of ray as a series, corresponding to each adambulacral plate, with about 10 spinelets. In the proximal portion of ray the second short series of ventrolateral plates present.

Adambulacral armature composed of about 10 to 15 pointed spines, the inner three or four being longer and stouter than the others. Furrow spines single, long and slender, the tip sometimes reaching the middle of a subambulacral spine just above.

Madreporite situated about midway between the centre of disc and the margin, densely covered with spinules.

Localities. Off Goto Islands, Tugaru Strait, off Seto.

Henricia aspera FISHER

(Pl. 7, figs. 9, 10.)

Henricia aspera: FISHER, 1906, p. 127; —— 1911, p. 293, pl. 75, figs. 1–5.

Specimens examined are related to *H. pacifica,* but are distinct in having simple adambulacral armature; aboral skeleton ridged, more open meshed; and marginal plates more prominent than in the species. They exactly agree with the description of *Henricia aspera* by Fisher. Two specimens examined, the measurements and localities being as follows:

R	r	R:r	Locality	Collection	Station
40mm	8mm	5	off Sado Id.	Sōyōmaru	605
48mm	8mm	5.1	————	Sōyōmaru	—

Diagnosis. Rays five, long and slender. R about 5r. Aboral skeleton ridged, forming an open mesh; papular areas sunken, each

with 1 to 7 papulae. Paxillae with mostly 5 or 6 small spinelets in group or more or less in curved series. Marginal plates discernible, but not conspicuous as in *leviuscula*; intermarginal plates reaching one-third the length of ray; with a short secondary series. Adambulacral armature composed of 5 to 7 bluntly pointed spines in two transverse or a zigzag rows; furrow spines single, but distally double.

Description. Disc small, rays long and slender. Aboral skeleton open meshed and ridged. Aboral paxillae small, mostly each with 5 or 6 (4–10) spinelets in group or in one or two irregular series

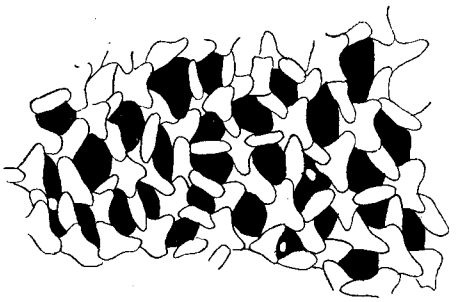


Fig. 44

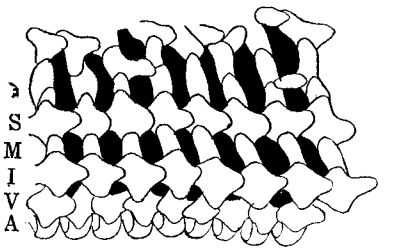


Fig. 45

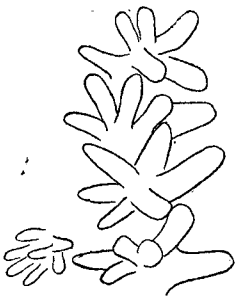


Fig. 46

Fig. 44. *Henricia aspera*; aboral plates in the proximal portion of ray. 7×.

Fig. 45. *Henricia aspera*; marginal and ventrolateral plates in the proximal portion of ray. S, superomarginals; I, inferomarginals; M, intermarginals; V, ventrolaterals; A, adambulacrals.

Fig. 46. *Henricia aspera*; adambulacral spines in the middle of ray. 17×.

encircling papular areas. Papular areas large, sunken, with 1 to 6 papulae in an area, containing sometimes smaller ossicles with 1 to 2 spinelets.

Marginal plates arranged in two regular rows: Superomarginal plates nearly equal to or a little smaller than inferomarginals, each bearing about 5 to 7 spinelets in one or two irregular transverse series; inferomarginals, opposite in position to superomarginals, with 7 to 13 spinelets in two irregular transverse series. Superomarginals

not bending upward abruptly; and being separated from the inferomarginals by a series of intermarginal plates with 3–5 spinelets, which extend to about one-third the length of ray. Ventrolateral plates arranged in a series, extending about two-third the length of ray, each with 5 to 7 spinelets. They are each corresponding to an adambulacral plate, but not exactly to the inferomarginal plates, the former being a little more numerous than the latter. A short series of the secondary plates present. Between these regular series of plates are found•series of papular areas containing 1 or 2 papulae in an area.

Adambulacral armature simple, composed of 5 to 7 bluntly pointed spines arranged in two transverse or a zigzag row, occasionally in a transverse row in the distal portion of ray. Spines having somewhat a tendency of budding. Furrow spines single, double distally.

Madreporite covered with spinules, situated about midway between the centre of disc and the margin.

Locality. Off Sado Island.

Distribution. From Bering Sea southwards along the coast to the Santa Barbara Islands, California and Japan.

Henricia Ohshimai HAYASHI

(Pl. 9, figs. 5, 6.)

Henricia sanguinolenta var. *Ohshimai*: HAYASHI, 1935, pp. 1–6, 7 Textfigs.

Specimens recently examined by the writer agree with the description of *Henricia sanguinolenta* var. *Ohshimai*. Judging from the recent works of Heding ('35, '36), the species is not *sanguinolenta*, because the skeletal structure and adambulacral armature are different and rays are shorter. Such being the case, the writer raised the variety to the rank of the species. The measurements and localities are as follows:

R	r	R:r	Depth	Locality	Collection
14mm	4mm	3.5	shore	Onagawa	Onagawa survey
35mm	8mm	4.4	„	„	„
48mm	10mm	4.8	„	„	„
35mm	8mm	4.4	200 M	between Hatijyo & Mikura Is.	Sōyōmaru

Diagnosis. Rays five, moderately long, gradually tapering to blunt tips. R about 3.5 to 4.5r. Aboral skleton open meshed, plates reticulated; paxillae not in distinct groups, more or less in series on the ridges of skleton; papular areas large, more or less sunken, with 1 to 5 pores. Marginal plates discernible, but never so conspicuous as in *leviuscula*; intermarginal and ventrolateral areas considerably wide; ventrolateral plates not reaching the tip; the secondary plates usually present. A few adambulacral spines arranged in a zigzag or in a transverse rows; furrow spines single, rarely double near the very tip.

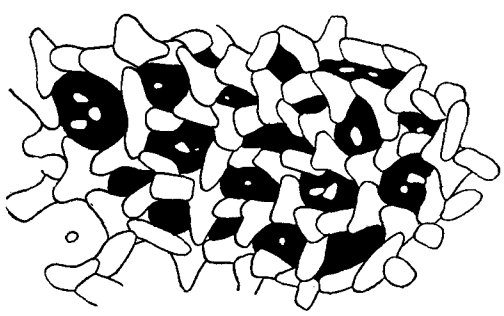


Fig. 47

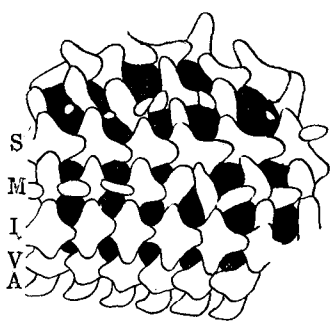


Fig. 48

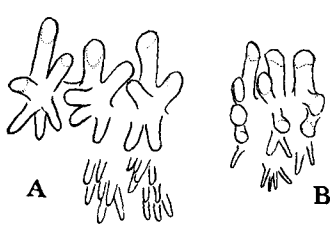


Fig. 49

Fig. 47. *Henricia Ohshimai*; aboral plates in the proximal portion of ray. 7×.

Fig. 48. *Henricia Ohshimai*; ventrolateral skeleton in the middle of ray. S, superomarginals; I, inferomarginals; M, intermarginals, V, ventrolaterals; A, adambulacrals.

Fig. 49. *Henricia Ohshimai*; adambulacral spines; A, in the proximal portion of ray; B, in the distal portion of ray. 12×.

Description. Aboral skeleton ridged, open meshed, the plates reticulated; subtriangular or four-lobed plates connected by smaller rounded or elongated plates. Papular areas rather large, sunken, each with 1 to 5 papulae and the areas occasionally are subdivided by smaller ossicles or granules with 1 to 3 spinules. Paxillae, each with 4 to 15 spinelets not in distinct groups, generally in 1 or 2 curved series surrounding papular areas, though occasionally in groups.

Marginal plates, never so regularly as in *leviuscula*, arranged in two longiseries. Both the series gradually diverge from the distal portion of ray, so the intermarginal area becomes prolonged and wide at the arm base. Intermarginal plates connected longitudinally by connecting plates; in the proximal portion of ray there are found three rows of papular areas, each with generally a single papula. Marginal paxillae with 5 to 10 small spinelets similar to the adjacent aborals.

Ventrolateral plates, each with 5 to 7 spinelets, opposing to each adambulacral plate, but not exactly to inferomarginals, reaching 2/3 to 3/4 the length of ray. In the proximal portion of ray are found the secondary series reaching about 1/3 of ray. They are longitudinally connected by smaller plates, where 2 series of papular areas occur, each with a single papula.

Adambulacral armature composed of 5 or 8 spines in two alternate or in a transverse rows, the two or three inner being larger than the outers; furrow spines single, but double near the very tip.

Madreporite circular, having spinelets on the ridges, situated about midway between the centre of disc and the margin.

Localities. Amakusa, Onagawa and between Hatijyo and Mikura Islands.

Remarks. From Japanese waters several specimens of *H. sanguinolenta* have been reported by several authors: Ives ('91), Döderlein ('02), Fisher ('11) and Uchida ('28). Verrill ('14) suggested that Ives' *sanguinolenta* with only figures and without description is not the very species but may be called *Henricia japonica*. Judging from Ives' figures it bears some resemblances to *Ohshimai*. Concerning Döderlein's *sanguinolenta* it is very difficult to identify it from his brief description, but it must be noted that he regarded *H. densispina* as a synonym of the species. Fisher's *sanguinolenta* of the Kurile Islands is seemingly not belonged to *Ohshimai*-group, and Uchida's species of Mutsu Bay is probably referable to the present species.

Henricia Ohshimai forma ***acutispina*** n. forma

(Pl. 10, figs. 5, 6.)

The present species is related to *Henricia Ohshimai* in general appearance, but differs from the type species in having more tapering

rays and slender adambulacral spines, and the ventrolateral and intermarginal areas which are poorly developed. It may be a deep water form of the species. Three specimens were examined, the measurements being as follows:

R	r	R:r	Locality	Depth	Collection	Station
31mm	6.5mm	4.7	off Rebun Id.	142fms	Albatross, 1906	4993
26mm	5 mm	5.2	off Kii Channel	200M	Sōyōmaru	232
20mm	5 mm	5	off Kii Channel	200M	Sōyōmaru	232

Diagnosis. Rays five, rather slender, tapering to the tip. R ranging 4 to 5.2r. Aboral skeleton open meshed; papular areas

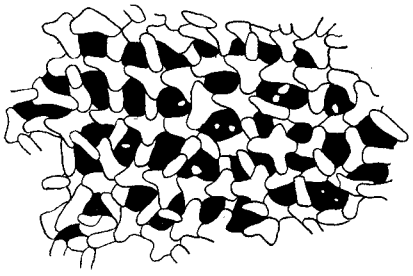


Fig. 50

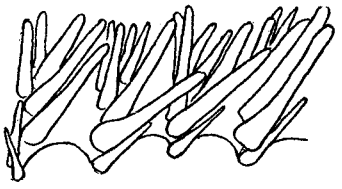


Fig. 52

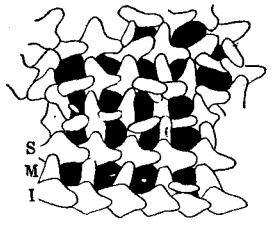


Fig. 51

Fig. 50. *Henricia Ohshimai* forma *acutispina* n. forma; aboral plates in the proximal portion of ray. 5×.

Fig. 51. *Henricia Ohshimai* forma *acutispina* n. forma; dorsolateral skeleton in the proximal portion of ray. 5×. S, superomarginals; I, inferomarginals; M, intermarginals.

Fig. 52. *Henricia Ohshimai* forma *acutispina* n. forma; adambulacral spines in the proximal portion of ray. 10×.

rather large, paxillae not in distinct groups. Marginal plates discernible, but never conspicuous; intermarginal area a little narrower than in *Ohshimai;* a second series of ventrolateral plates present. Adambulacral armature composed of 5 or 6 slender long spines; furrow spines single or double.

Description. Aboral skeleton open meshed, resembling *Ohshimai* in structure. Aboral paxillae small, composed of 3 to 7 small pointed spinelets in a single or double series. Papular areas rather

large, containing 1 to 6 papulae in an area and occasionally with small ossicles.

Marginal plates discernible, but never conspicuous; the superomarginal plates, opposite in position to the inferomarginals, gradually bend upward and both the series very gradually diverge, so the intermarginal area becomes narrow and prolonged, containing a short series of intermarginal plates, not extending beyond the middle of ray. Marginal paxillae similar to those of aboral plates, 9 to 12 spinelets in each. Ventrolateral plates extending 2/3 length of ray, each with 5 to 8 spinelets, generally opposite to inferomarginal and adambulacral plates. Near the arm base is found a short series of the secondary plates.

Adambulacral armature composed of 5 or 6 long slender spines, arranged in two alternate rows; the inner three being much longer and stouter than the outers. Furrow spinelets single or double.

Madreporite with spinules, situated about midway between the centre of disc and the margin.

Localities. Off Rebun Island and of Kii Channel.

Henricia pachyderma n. sp.[1)]

(Pl. 7, figs. 1, 2.)

The present sea-star is a very characteristic species of *Henricia* and undoubtedly belongs to a new form.

Diagnosis. The whole body is covered with a rather thick skin. Disc small, rays thick and broad, constricted at the base, five in number. R being 4.4 to 6r. Aboral skeleton open meshed, papular areas large, but papulae not numerous. Aboral paxillae immersed in the skin, each bearing 5 to 10 small spinelets in a group. Marginal plates gradually diverge laterally from the tip of ray; intermarginal and ventrolateral areas very spacious, the plates being arranged regularly. Adambulacral spines 5 to 6, arranged in two transverse rows or in a zigzag. Furrow spines single. Seven specimens were examined, the measurement being as follows:

1) The specimens were labelled as *H. pachyderma* by the late Prof. S. Goto who provisionally named these specimens but without description.

R	r	R:r	Locality	Collection
44mm	10mm	4.4	Hozyo	Goto, 1894
47mm	10mm	4.7	Hozyo	Goto, 1894
60mm	10mm	6	Misaki	Goto, 1911
65mm	11mm	5.9	Misaki	Goto, 1911
67mm	12mm	5.6	Misaki	Goto, 1911
70mm	13mm	5.3	Hozyo	Goto, 1894–*Type*
84mm	15mm	5.6	Misaki	Goto, 1911

Description. Aboral skeleton open meshed, composed of roundish, rod-like or lobed plates, various in size. They are arranged

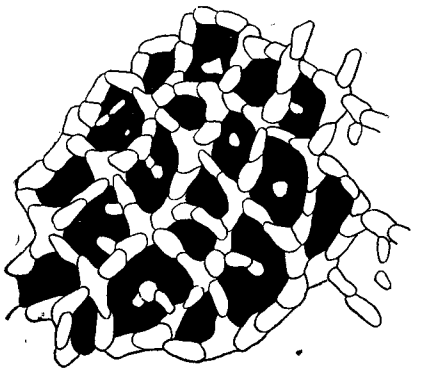


Fig. 53

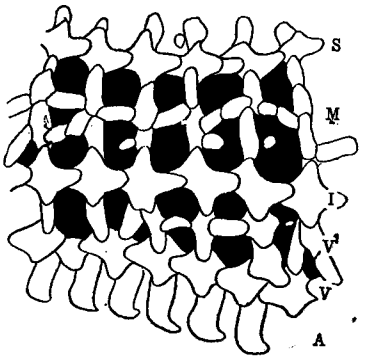


Fig. 54

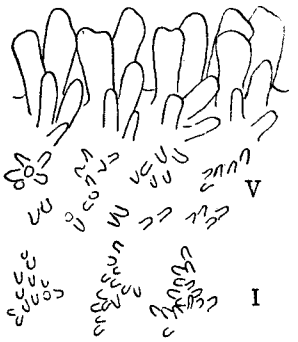


Fig. 55

Fig. 53. *Henricia pachyderma* n. sp.; aboral plates in the middle portion of ray. 5×.

Fig. 54. *Henricia pachyderma* n. sp.; ventrolateral skeleton in the middle of ray. S, superomarginals; I, inferomarginals; M, intermarginals; V, ventrolaterals; V^1, secondary ventrolaterals; A, adambulacrals.

Fig. 55. *Henricia pachyderma* n. sp.; adambulacral spines in the middle portion of ray. 7×. V, ventrolateral spines; I, inferomarginals.

in more or less oblique transverse series, papular areas being large and somewhat rhombic-shaped, with 1 to 3 but rarely 4 papulae in an area. Aboral paxillae immersed in the integment, each with 5 to 10 small spinelets in a group.

Marginal plates undiscernible in the surface view. Both the marginals gradually diverge from the tip of ray, bending upward, so the intermarginal area is very spacious. Marginal plates cruciform, a little larger than the adjacent aborals. Intermarginal plates elongated rod-like in form, connecting with each other regularly in transverse and longiseries, though the longiseries being more or less irregular. Papular areas situated in 2 or 3 regular longiseries, subquadrate in form, with 1 or 2 papulae in an area. Marginal paxillae each with 7 to 15 spinelets similar to the aborals.

Ventrolateral area becoming wide toward the arm base by the bending of inferomarginal plates. Plates adjacent to adambulacral plates extending to the tip of ray, corresponding to the latter in number, with 5 to 12 spinelets. Between the ventrolateral and the inferomarginals are found numerous secondary rod-like plates, similar in the arrangement to the intermarginals. In the proximal portion of ray there are two series of subquadrate papular areas, each with mostly a single papula.

Adambulacral armature composed of 5 to 6 spines arranged in two transverse rows or a zigzag row, the two or three facing the furrow being compressed, much larger than the others. Furrow spines usually single.

Madreporite small, with spinules like those of the adjacent aborals, situated about halfway between the centre of disc and the margin.

Localities. Hozyo and Misaki.

Henricia reticulata n. sp.

(Pl. 9, figs. 1, 2.)

The present species is very characteristic in the skeletal structure devoid of regular arrangement of marginal plates and in having large disc and broad rays. Two specimens were examined, the measurements and localities being given below:

R	r	R:r	Locality	Depth	Collection
49mm	11mm	4.5	Muroran	shore	M. Iwasa, 1934
71mm	17mm	4.5	Onagawa	——	Onagawa Survey–*Type*

Diagnosis. Disc large, rays five, broad at the base, gradually tapering. R about 4.5r. Aboral paxillae in groups. Aboral skeleton

reticulated; papular areas rather small. Marginal plates indistinguishable. Ventrolaterals adjacent to adambulacrals reaching the tip. Adambulacral spines 4 to 7, bluntly pointed, arranged in two or a zigzag rows; furrow spines single.

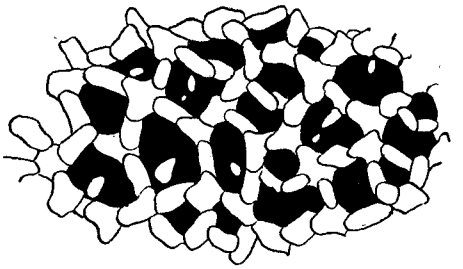


Fig. 56

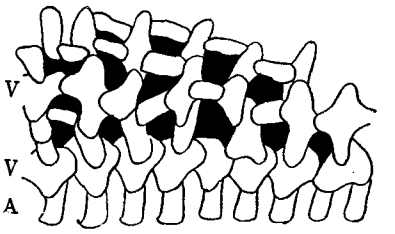


Fig. 57

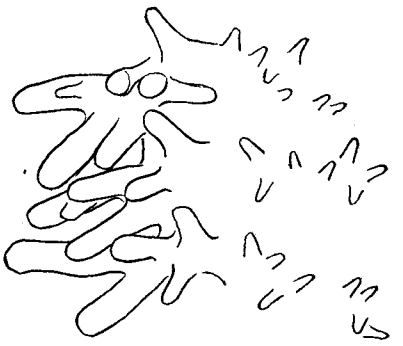


Fig. 58

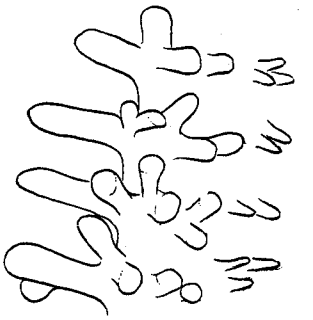


Fig. 59

Fig. 56. *Henricia reticulata* n. sp.; aboral plates in the middle portion of ray. 7×.

Fig. 57. *Henricia reticulata* n. sp.; ventrolateral skeleton in the proximal portion of ray. 7×. V, ventrolateral plates; A, adambulacrals.

Fig. 58. *Henricia reticulata* n. sp.; adambulacral spines in the proximal portion of ray. 17×.

Fig. 59. *Henricia reticulata* n. sp.; adambulacral spines in the distal portion of ray. 17×.

Description. Disc relatively large, rays broad at the base, but not constricted. Aboral skeleton reticulated, composed of relatively slender, 3- or 4-lobed and elongated rod-like plates. Aboral paxillae small, each with 5 to 18 small spinelets in group; papular areas rather small, containing 2 to 6 papulae in an area.

Marginal plates not discernible except near the arm tip. When denuded, they show somewhat an indication of diverging from near the arm tip, leaving intermarginal and ventrolateral areas being large and wide. The plates in the areas are similar to aborals. Ventrolateral plates adjacent to adambulacrals prominent, arranged in a distinct series, corresponding in number to the latter, each with 2 to 7 small spinelets.

Adambulacral spines 4 to 7 in number, bluntly pointed and arranged in two transverse or in a zigzag rows and distally in a transverse row. It is to be noted that the spines have a tendency of budding. Furrow spines single.

Madreporite situated about midway between the centre of disc and the margin, covered with small spinelets similar to the adjacent aborals.

Remarks. The present species is more or less related to *Henricia sanguinolenta* of Fisher, but differs in short and broad rays, fewer adambulacral spines, wide intermarginal and ventrolateral areas. In having reduced marginal plates it resembles *Henricia irregularis* n. sp., but evidently differs from the species in other characteristics.

Localities. Onagawa and Muroran.

Henricia irregularis n. sp.

(Pl. 4, figs. 1, 2.)

The present species shows a peculiar form differing from the members of the genus in the skeletal structure; in having very small, low slender skeleton and marginal plates exceedingly reduced. The species seems to be more or less related to *Henricia clarki,* but very distinctly differs from it in the skeletal structure and other characteristics. A single specimen was examined, measuring 88 mm in R, 14 mm in r.

Diagnosis. Rays five, flexible, gradually tapering, R about 6r. Aboral skeleton forming more closed meshes than in *H. clarki,* composed of very small low plates reticulating with each other; papular areas very small, each with a single papula. Marginal plates rudimentary, but seemingly arranged in two rows, diverging gradually; marginal areas spacious. Ventrolateral areas wide at arm base, and no regular series of plates as in other species. Adam-

bulacral spines numerous, 10 to 23 in number, arranged in irregular transverse series; furrow spines double.

Description. Aboral plates small, low, very closely crowded, rod-like in form, reticulating with each other and meshes irregular in form, subdivided by slightly smaller plates into smaller papular

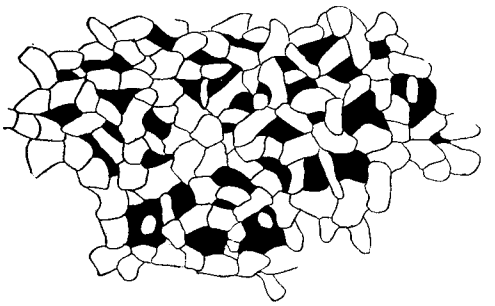


Fig. 60

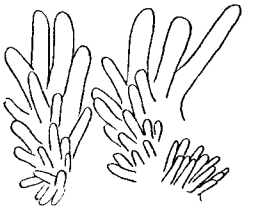


Fig. 62

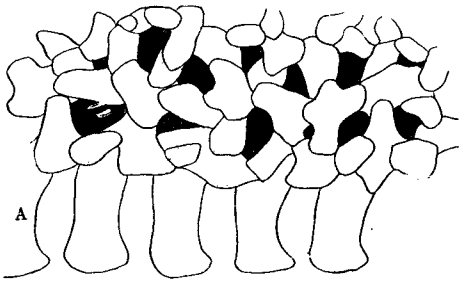


Fig. 61

Fig. 63

Fig. 60. *Henricia irregularis* n. sp.; aboral plates in the middle portion of ray. 12×.

Fig. 61. *Henricia irregularis* n. sp.; ventrolateral skeleton in the middle of ray. 12×. A, adambulacral plates.

Fig. 62. *Henricia irregularis* n. sp.; adambulacral spines in the middle portion of ray. 12×.

Fig. 63. *Henricia irregularis* n. sp.; adambulacral spines in the distal portion of ray. 12×.

areas, with a papula in each. The aboral surface shows a smooth appearance. Paxillae very small, closely crowded, each with 4–5 (2–9) minute spinelets which become gradually coarse toward the ventral sides of ray. The marginal ones are not distinguishable from the others.

Marginal plates quite inconspicuous. When denuded, two series of plates are observed, sightly larger than the neighbours, but never so distinct as in other species. They are probably the representatives of marginal plates. The series gradually diverge toward the arm base, though in the distal portion of ray the superomarginal one being undiscernible. The intermarginal areas are spacious, containing numerous small plates in meshes as in the aboral surface.

Ventrolateral plates not arranged in any regular row. The areas are spacious at the base of ray, containing small plates in meshes.

Adambulacral plates with each about 12 to 23 graded slender spinelets (proximally about 20, distally about 10) arranged more or less in three irregular transverse rows. Furrow spines mostly double, the innermost ones being short and slender.

Madreporite circular, situated about midway between the centre of disc and the margin.

Locality. Yezo Strait (Albatross' station, 5031 in 1906); 86 fathoms in depth, nature of bottom dark sand and gravel.

Genus *Poraniopsis* PERRIER

Poraniopsis: PERRIER, 1888, p. 763 (nomen nudum); 1891, p. 105, pl. 10, figs. 2a, 2b; FISHER, 1911, p. 260 (with synonymy).

The genus differs from other two genera, *Henricia* and *Echinaster,* in having short and wide rays; stout skeleton in wide meshes; no spinelets deep in furrow; Polian vesicles present. The writer doubts as to the systematic position of the genus. The genus is more or less related to Acanthasteridae; body covered with a rather thick skin; aboral skeleton wide meshed, bearing upright prominent isolated spines at the nodes; papular areas large with numerous papulae and granules; no ventrolateral papular areas; no spinelets deep in furrow; Polian vesicles present. *Acanthaster,* however, distinctly differs from *Poraniopsis* in having numerous rays and madreporites; numerous upright two-jawed pedicellariae; much prominent spines; tube-feet with double ampullae; in adambulacral armature. The writer, therefore, suggests that *Poraniopsis* is a distinct group which is related to two Families, Echinasteridae and Acanthasteridae.

Poraniopsis inflata (FISHER)

(Pl. 4, figs. 9, 10.)

Poraniopsis inflata: FISHER, 1911, p. 261, pl. 58, figs. 7, 7a, pl. 63, figs. 1, 2, pl. 112, fig. 1.

Five specimens examined, the measurements being as follows:

R	r	R:r	Locality	Depth	Collection	Station
43mm	15mm	2.8	off Miyako		S. Koyama	
50mm	16mm	3.1	Northern part of Honsyu		T. Uchida	
50mm	20mm	2.5	off Kinkasan	129 fms	Albatross, 1906	5048
57–48mm	20mm		Northern part of Honsyu		T. Uchida	
77mm	29mm	2.6	Onagawa		Onagawa survey	

Diagnosis. Whole the body covered with a rather thick skin, oral side subflattened. Rays five, broad, robust, R about 2.5–3r. Aboral skeleton ridged, forming much wide meshwork; the spines at the nodes large and isolated; large aboral and intermarginal papular areas with numerous papulae and granules; no ventrolateral ones. Marginal and ventrolateral spines arranged in regular series; adambulacral armature composed of two stout spines, none deep in furrow.

Description. Aboral skeleton forming very open net work, composed of 3-, 4- or 5-lobed, slightly raised tuberculated plates connected by several rod-like, oblong overlapping ossicles. The meshes form low raised ridges, separating papular areas distinctly, but in small specimens the ridges are not so conspicuously raised. Papular areas very spacious, subquadrate or irregular shaped, containing about 50 or more pores in an area and fine granules arranged more or less in lines. Isolated long aboral spines occur at the corners of papular areas. Carinal spines arranged more or less in a longiseries, but with growth becoming to have a tendency to be zigzag from the proximal portion of ray toward the distal portion. Spines stout, tapering, usually rather sharp, about 3.5 to 5 mm in length. There is a series of dorsolateral spines nearly equal to the carinals in size and form. Spines arranged in a longiseries or more or less in a zigzag row. Between the carinal and dorsolateral series is frequently found a rudimentary series represented by two or three

spines. Primary radial, interradial and central plates and spines not so conspicuous enough to be distinguishable from the secondary ones, but being barely discernible by the position. The primary plates frequently bear two spines. The plates and spines are covered with a rather thick skin.

Superomarginal spines arranged in regular series, forming the lateral margin of ray. The spines are slightly larger than the aborals and pointed rather sharply, one or frequently two for a plate. Inferomarginal spines, mostly one, rarely two, for a plate, separated from the superomarginals by a series of wide papular areas in regular longiseries. The spines in the proximal portion of ray are a little larger than the superomarginals, with the tips which are truncated, compressed and shallowly grooved on the outer side. Intermarginal spines absent, when present, they are few.

Ventrolateral spines arranged in regular two series parallel to the inferomarginals; the outer series extending slightly beyond the middle of ray, gradually decreasing in size toward the tip, and the inner one is rudimentary, represented by several spines. The spines are similar to the inferomarginals in form, those situated in interbrachial areas being slightly wider at the tip than the base, gouge in form. Fine creases in the integment proceed outward between the spines, from the adambulacral to marginals.

Adambulacral armature composed of spines in two series. The furrow spines, one for each plate, are truncated, compressed at the tip, having a groove on the outer side. The outer spines are larger than the furrow spines, flattened, truncated, gouge-shaped, and wider at the tip than the base. Both spines are covered with membrane, as in the ventrolateral surface. Mouth plate with one suboral and four furrow spines. The furrows are flattened, truncated, decreasing in length toward the first adambulacral plate, and the suboral spine is similar to the following subambulacral spines in size and form.

Anal aperture surrounded by many slender papilliform spinelets. Madreporite prominent slightly convex, roundish in form, situated at about the middle of minor radius.

Remarks. Fisher ('11) mentioned a Japanese specimen of *Poraniopsis* as follows: "I have examined a large *Poraniopsis* from off Honsyu, Japan, 182 fathoms, which differs in a few details from *inflata* and probably represents a different though closely related

species". Recently he ('39) described the specimen under the name of *Poraniopsis japonica,* giving the following diagnosis: Differing from *P. inflata* (Fisher) in having a larger disk, rays broader at base, a decidedly broader abactinal area with more numerous abactinal spines, numerous delicate thorny spinelets immersed in the thick membrane of papular areas more widely spaced inferomarginal spines, adambulacral spines without well marked grooves. R-77 mm, r-38 mm, R-2r. So far as the writer's observation go, there are considerable variations in this species: Rays considerably diverse in width, even in specimens obtained from the same locality; aboral spines also widely spaced or more crowded and the carinal spines in a zigzag or in a series. Adambulacral spines well marked with groove or not well. The delicate thorny spinelets in papular areas are not so numerous as in *japonica.* The writer, therefore, identified specimens with *P. inflata* (Fisher).

Localities. Off Miyako, Kinkasan, Onagawa, northern part of Honsyu.

Distribution. Oregon to Sandigo, California and Japan.

Family Acanthasteridae FISHER, 1911

Acanthasteridae: FISHER, 1911, p. 252.
Acanthasterinae: SLADEN, 1889, p. 536.

Differing from Echinasteridae in having double ampulae and Polian vesicles; well developed interbrachial septa, numerous madreporites; upright two-jawed pedicellariae; rays numerous. In Japanese waters only a species, *A. planci,* is known.

Acanthaster planci (LINNÉ)

Acanthaster planci: FISHER, 1919, p. 441; CLARK, 1921, p. 101; HAYASHI, 1938 (b), p. 442, pl. 4, figs. 3, 4.

The remarkable sea-star is common in Palao, living on sandy bottom or on rocks near the low tide line. The colour in life is deep violet with reddish patterns corresponding to papular areas on the disc and the proximal portion of ray. They lack rarely the pattern.

Diagnosis. Body covered with a thick skin. Disc discoidal, rays relatively short, wide at the base, 11 to 16 in number. R

about 2r. Aboral skeleton open meshed, papular areas well developed. Aboral spines isolated, very prominent with sharp tips. Sharp two-jawed pedicellariae present. Marginal plates inconspicuous. Adambulacral plates armed with three spines on the furrow margin and a stouter spine behind them. Madreporites variable in number, 4 to 9. Tube-feet with two ampullae, Polian vesicles present.

The measurements of Palao specimens were already given by the writer as follows:

R	r	R:r	Rays in number	Madreporites in number
85mm	45mm	1.9	14	6
98mm	54mm	1.8	13	4
103mm	56mm	1.8	14	8
112mm	59mm	1.9	14	5
116mm	54mm	2.1	11	6
117mm	68mm	1.7	14	7
138mm	70mm	1.9	16	6
150mm	72mm	2.1	11	6

Description. Aboral skeleton widely open meshed, especially in rays, and covered with a membrane beset with calcareous granules. Aboral spines consist of two parts; the pedicel or column being homologous with aboral ossicles and the movable spine articulated to the former. The pedicels are about 5 mm long, the spines about 20 mm long in large spines. Occasionally two small, short spines occur on a pedicel. There are a large number of two-jawed pedicellariae which are long and slender, about 2–2.5 mm long. The aboral surface is occupied with papular areas containing numerous papulae. The areas on rays are confined to the proximal portion and both the sides which probably correspond to intermarginal areas.

Marginal plates inconspicuous, hardly recognizable. Ventrolateral plates arranged in longiseries. The first series, adjacent to adambulacral plates, reaches two-thirds the ray, and the second and third are short, not extending to the oral side of ray. Ventrolateral spines, one for each plate, similar to subambulacral spines.

Adambulacral plates wider than long, armed with two series of spines. Furrow series composed of three slender spines in each plate, the middle one being the longest, the other two smaller and stubby. Subambulacral series composed of prominent spines, one for each plate. The spines are much longer and stouter than those near the furrow and are grooved on the outer side of the tip. Adam-

bulacral pedicellariae present or absent. When present, prominent tapered two-jawed pedicellariae occur on the adoral edge of each plate.

Madreporites hemispherical in form, situated near two-third the distance from the centre of disc to the margin. They are very variable in number, 4 to 9. There is no correlation between the number of rays and that of madreporites, but the number of madreporites is related to that of Polian vesicles, in the madreporic interradius usually two vesicles observed.

Locality. Palao Is.

Distribution. Widely distributed in the Indo-Pacific, from Zanzibar, the Arabian Gulf and Red Sea to the Society and Hawaiian Islands, Philippines, Moluccas, Fiji, Samoa Islands, Mauritius, Torres Strait, Queensland. Palao and the Ryukyu Islands in Japan.

Family Mithrodiidae PERRIER, 1894

Mithrodiidae: PERRIER, 1894, p. 4; FISHER, 1906, p. 1094; FISHER, 1911, p. 252.

The family contains only one genus, *Mithrodia* Gray, and differs from Echinasteridae in having double ampullae, in lacking interbrachial septa and in the whole body covered with a rather thick skin beset with rough granules, tubercles and spinelets.

Mithrodia clavigera (LAMARK)

Mithrodia clavigera: PERRIER, 1875, p. 378; LORIOL, 1885, p. 13, Pl. 11, fig. 1; HAYASHI, 1938 (d), p. 216, pl. 2, figs. 8–10; ——, 1938 (e), p. p. 287, pl. 6, fig. 1, pl. 7, figs. 1–3.

This tropical sea-star is known from the Ryukyu Islands and Seto in Japan. The colour in life is gray with darker, large, irregular transverse patterns or gray with irregular transverse, blackish and pale pinkish red patterns.

Diagnosis. Body covered with a rather thick skin beset with rough granules, scales and spinelets. Disc small, rays five, long, unequal in length, so the ratio of R:r is diverse, as is shown in the following table. Aboral skeleton open meshed, papular areas various in size. Marginal plates inconspicuous. Aboral, marginal and

ventrolateral spines large, obtuse, widely spaced. Adambulacral armature composed of two series of spines, those near the furrow margin being arranged palmately, behind them a larger subambulacral spine exists.

The following measurements are already given by the writer.

R	r	R:r	Locality
58mm–178mm	15mm	3.9–12.5	Seto
120mm–182mm	13mm	9.2–14	Seto
198mm–235mm	15mm	13.2–15.7	Seto
263mm–284mm	24mm	10.9–11.8	Seto
65mm– 86mm	10mm	6.5– 8.6	Yaeyama Is.
70mm–108mm	12mm	5.8– 9	Okinawa Is.

Description. Disc small, rays long and narrow, unequal in length, subcircular in cross section, more or less broader than high.

Aboral and marginal skeleton composed of small rod-like plates, forming low ridges and roughly reticulated in the form of triangles, grouped in hexagon. Papular areas various in size, containing numerous papulae, seven to more than thirty in an area separated by the ridges of skeleton. In the areas are also found small granules and pedicellariae. The uniquely formed pedicellariae are confined to the areas near the furrow, one or two in an area. The organ is formed of a main body and several slender, recurved teeth. A number of plates in carinal and marginal regions are tuberculated, roundish in form, each with a prominent obtuse spine. The spines are widely spaced, arranged more or less in longiseries, though inconspicuous in the distal portion of ray. Marginal spines arranged in two series, extending to the arm tip. Superomarginals fewer and slightly larger than the inferomarginals; in a ray of one specimen (R 108 mm) the supereromarginals are about 3 mm–4 mm in length, 11 in number and the inferomarginals are about 2.5 mm–3.5 mm in length, 18 in number. The whole body including spines, is covered with a rather thick granular skin. The granules on the spines and spinelets are roundish or elliptical in form, coarser than those of the skeletal ridges and papular areas, where the granules are small, mostly roundish in form.

Ventrolateral plates, juxtaposed to each adambulacral plate, arranged in a series, extending to the arm tip. These plates are unequal in size, the large and small ones having a tendncy to be arranged in alternate position. The ventrolateral spines like to

those of the inferomarginals are located on every 6th or 7th plates, each measuring about 1.5mm–2.5 mm in length.

Adambulacral armature composed of spines in two series and granules. Furrow spines arranged palmately, eight to ten in number in each plate, with the longest one in the median, about 1.3 mm long; and the rest gradually decreasing in length toward both lateral sides. These spines are united with each other by a thin membrane. The subambulacral spins, one in each plate, are stout, obtuse, about 1.4 mm–1.8 mm long and each covered with granules identical with those of ventrolatral surface. Oral plates have each eight furrow spines and two suborals.

Madreporite small, roundish in form, situated about midway between the margin of disc and the centre.

Variations. In the specimens obtained from Seto, there are observed considerable variations in the aboral spines. In the two examples the aboral spines are large, prominent, well spaced, those on the carinal portion of ray being arranged more or less in longi-series, and a few spines occurring at random on the dorsolateral portion of ray. But in the other two examples, the aboral spines are more or less reduced, not prominent, and the knobs on aboral ridges are more numerous. Papular areas slightly smaller than those of the specimens having prominent spines. In these specimens the marginal and ventrolateral spines are also poorly developed, especially in the superomarginals, and the granulation covering spines is less coarser. But these specimens obtained from the same locality are closely allied in the other characteristics; in having similar pedicellariae and in adambulacral armature. The writer, therefore, identified these specimens with the present species.

Localities. Seto and the Ryukyu Islands.

Distribution. Widely distributed in the Indo-Pacific regions. The Ryukyu Islands and Seto in Japan.

Family Solasteridae PERRIER, 1884, emended

Spinulosa with more or less open reticulated aboral skeleton; rays variable, 5 to 13 or more; the plates bearing paxilliform groups of spinelets; marginal plates paxilliform, alternate or opposite or in a series and the superomarginals often much smaller; adambulacral

armature composed of a furrow comb and a series at right angle to it; ventrolateral plates present; interbrachial septa present; no pedicellariae; no supradorsal membrane; mouth plates large, furrow wide; tube-feet in two series, with well developed terminal sucker. In Japanese waters two genera of the family are known.

Key to Japanese genera of Solasteridae

a^1. Aboral skeleton close or open meshed; dorsolateral plates more or less in oblique transverse rows; paxillae small, not penicillate; marginal paxillae in one or two series. ..... ***Solaster*** FORBES

a^2. Aboral skeleton wide meshed; dorsolateral plates forming no regular rows; paxillae large, spaced, penicillate; marginal paxillae in one row. ..... ***Crossaster*** (M. & TR.)

Genus *Solaster* FORBES

Solaster: FORBES, 1839, p. 120. Type, *Asterias endeca* LINNÉ.
Solaster (subgenus *Endeca*): GRAY, 1840, p. 183. Type *Solaster endeca*.
Solaster (part): FISHER, 1911, p. 306.

Key to Japanese species of *Solaster*

a^1. Marginal paxillae in two series; the superomarginals much smaller than the inferomarginals and situated just above or alternating with them. Aboral skeleton closely meshed.

b^1. Aboral paxillae small, spaced or crowded. Marginal paxillae low. Furrow spines not conspicuously long and bristling.

c^1. Paxillae very small, crowded, with 5 to 10 small spinelets. Disc large, rays rather short. Inferomarginals opposite or alternating with superomarginals, with about 20 or more spinelets. Furrow series having 1 to 3 spinelets and subambulacral series with 4 spines. ..... ***endeca***

c^2. Paxillae more spaced, with more numerous spinelets, less than 20. Furrow series with 2 to 4 spinelets and subambulacral series 4 or 5 spines. (The species seems to have considerably variable forms). ..... ***stimpsoni***

b^2. Aboral paxillae large. Marginal paxillae prominent, forming a conspicuous border to rays. Furrow spines long and bristling.

c^1. Subambulacral comb curved; superomarginals typically alternating with inferomarginals; oral interradial areas large; aboral interradial areas more or less free from paxillae. Furrow series having 4 (2–6) spines and subambulacral series 5 or 6 spines.... ***paxillatus***

c^2. Subambulacral comb straight; superomarginals typically opposite to inferomarginals; oral interradial areas very small; furrow spines stouter.

d^1. Aboral paxillae large, tabulate; furrow series with 3–4 (2–6) spines and subambulacral series 5 to 7 spines..... ***dawsoni***

d^2. Aboral paxillae much smaller and crowded; furrow series with 2–3 spines and subambulacral spines 5–6. ..... ***intermedius***

a^2. Marginal paxillae in one or two series. Aboral skeleton more or less open meshed. Inferomarginal plates very conspicuous, well spaced. Bare aboral interradial streaks marked.

b^1. Furrow spines much shorter than subambulacral spines. Inferomarginal plates with a few spines in a series.

c^1. Aboral paxillae small, spaced, with 1 to 4 spinelets. Bare interradial streaks well marked. Inferomarginal paxillae prominent, well spaced; superomarginals indistinguishable. Furrow spines unequal in length. ..... ***borealis***

c^2. Aboral paxillae large, widely spaced on disc, with 10–20 spinelets; bare interradial streaks marked. Marginal paxillae in two series; superomarginals much smaller than inferomarginals, alternating with them. Furrow spines subequal in length..... ***Uchidai***

b^2. Furrow spines long and stout, 2 or 3; marginal paxillae in a series, more or less penicillate, with 20 to 30 spinelets; sometimes like *Heterozonias;* superomarginals indistinguishable. Aboral paxillae with 2 to 20 spinelets; aboral skeleton very characteristic. ..... ***diamesus***

Solaster endeca (LINNÉ)

Solaster endeca: FISHER, 1911, p. 307, pl. 81, figs. 1, 2, 4; VERRILL, 1914, p. 244, pl. 9, figs. 2, 3, pl. 87, figs. 4–4b, pl. 89, fig. 1; HAYASHI 1939, p. 297, pl. 23, figs. 5–7.

Diagnosis. Disc large; rays variable in number, 8 (6 to 13), rather short; paxillae small, closely crowded; papulae single or double; inferomarginal plates low, transversely elongated; superomarginal plates small; inferomarginals opposite to or alternating with superomarginals; furrow series of 2 or 1 spines; subambulacral spines 4 in a recurved series.

Description. Three specimens were examined, measuring from 67 mm to 121 mm in R. R ranging 2.4 to 2.7r. The description of an example (R 78 mm) was already given by the writer ('39) as follows:

Aboral paxillae small and crowded, each with five to ten skin-covered spinelets. The paxillae on sides of ray are a little larger than those on disc and midradial portions of ray, arranged in oblique transverse series. Aboral ossicles small, closely crowded and imbricated, leaving small papular areas, each with one or two papulae.

The marginal plates seem to be relatively diverse in feature in individuals. Inferomarginals distinctly larger than the others, low, transversely elongated, nearly uniform in size, though those near the arm tip being small, numbering about 60 on sides of ray. These plates bear each about 19 to 24 small spinelets. Superomarginals, mostly situated directly above and close to the latter. They are one-half to one-third the size of the inferomarginals, roundish or subquadrate in form. They are somewhat larger than the adjacent aborals, carrying about 13–15 spinelets. In an example (R 121 mm) the superomarginals are opposite to the interspace between two inferomarginals and in size they are very small and hardly distinguishable from the adjacent aborals. In the Rakuma specimen (R 67 mm) the superomarginals alternate with the inferomarginals, and are a little larger than the neighbouring aborals.

Oral interradial area rather large. A series of paxillae extends to about the middle of the free part of ray. Interradial area crowded with paxillae bearing seven to ten spinelets.

In this Asiatic example (R 78 m) the adambulacral spines are fewer than those described by Verrill and Fisher for North Pacific and Atlantic specimens. Furrow spines conspicuously shorter than the subambulacral spines, two in the proximal portion of ray and only one in the distal portion. When there are two spinelets, the adoral one is usually slenderer and shorter. The subambulacral comb is slightly curved, not straight, composed of four skin-covered spines gradually decreasing in length from the inner ones toward the outer ones. Mouth plate with five or six oral spines, of which the adoral two at the apex of plate are stoutest and longest, then decreasing in length distally. On the surface of the plate there are three to five suboral spines arranged in a series or somewhat irregularly, not in two rows as in the type specimen. The specimen (R 121 mm) has one or two furrow spines, but the subambulacral comb is composed of more numerous spines than in the above stated specimen. In the middle portion of ray there are arranged five to seven subambulacral spines in a slightly curved series, but in the proximal portion of ray the spines increase in number, 12 to 25. The arrangement is variable; sometimes in two rows, occasionally in clusters or the inner ones in a row and the outer ones in two rows or clusters. The inner two spines are long and stout, but the rest are small, a little longer than or subequal to the adjacent oral

lateral spinelets. In the Rakuma example there are one, two or three furrow spines; when two present, the adoral one is small and when three present, the middle is the longest. Subambulacral spines four to six in a curved series. Mouth plates with six orals and four suborals in a series.

Madreporite large with several paxillae on its surface, situated midway between the centre of disc and the margin.

Localities. Rakuma, Saghalin and Tartary Gulf (Albatross station, 5003, 5004); depth 38 fathoms.

Distribution. Widely distributed in North Pacific and Atlantic Oceans.

Solaster stimpsoni VERRILL

Solaster stimpsoni: FISHER, 1911, p. 311, pl. 82, fig. 3, pl. 83, figs. 1–5; VERRILL, 1914, p. 254, pl. 10, figs. 1, 2, pl. 15, figs. 1, 2, pl. 46, figs. 1–1c, pl. 94, fig. 2, pl. 95; HAYASHI, 1939, p. 299, pl. 23, figs. 8, 9.

Diagnosis. Disc large, rays long relatively slender, 10 in number; aboral paxillae small, crowded; inferomarginal plates compressed; superomarginal plates exceedingly small, situated close to inferomarginals; furrow series of 2 to 4 spinelets; subambulacral spines 4 or 5 in a curved series.

A single speciemen was examined. The description was already given by the writer ('39) as follows:

A ten-rayed specimen obtained by Prof. T. Uchida from the North Pacific coast of Honsyu. It measures 88 mm in R, 27 mm in r and R about 3.3r. The specimen resembles the present species in general appearance, though the aboral paxillae are smaller and the suboral spines of mouth plate are more numerous.

Description. Disc of moderate width, rays tapering, long and slender. Aboral paxillae small, crowded, those on the disc being smaller and more crowded than on rays. The large paxillae have each about two to five central and nine to twelve marginal webbed spinelets. The paxillae are arranged in very oblique transverse rows on the sides of ray, but they show logitudinal arrangement in the distal portion of ray. Aboral plates three- or four-lobed, imbricating each other. Papulae single, rarely double in an area.

Inferomarginal plates much compressed, rather prominent, each bearing a large number of spinelets arranged mostly in two rows.

Superomarginals close to the inferomarginals exceedingly smaller than the latter, very slightly larger than the adjacent aborals.

Oral interradial areas rather large, paxillae each with two to eight spinelets. A series of the paxillae extends barely to the middle portion of ray.

Furrorw spines slender and acute, webbed in the basal half portion, numbering two in the middle and distal portion of rays, and three or four in the proximal portion. When four spines occur, the middle two are much longer than the lateral ones. Subambulacral comb composed of five or four spines in a slightly curved series. Mouth plate with ten oral spines, the adoral three being long and stout, while the others on the side of the plate much smaller. Suboral spines not arranged in a single series, numbering ten to twelve, the adoral four or five arranged in a series and the aboral ones in two rows or in irregularly set.

Madreporite rather small, situated about midway between the margin and the centre of disc.

Locality. North Pacific coast of Honsyu.

Distribution. North Pacific regions and southern Bering Sea.

Solaster dawsoni VERRILL

Solaster dawsoni: FISHER, 1911, pl. 84, figs. 1, 2, pl. 86, figs. 1, 2, pl. 113, fig. 1; VERRILL, 1914, p. 249, pl. 46, figs. 5–5b, pl. 90, fig. 1, pl. 91, figs. 1, 2, pl. 92, fig. 1; UCHIDA, 1928, p. 796, pl. 32, fig. 1; HAYASHI, 1939, p. 300, pl. 24, figs. 7, 8.

Diagnosis. Disc moderately large, rays 10 to 11, R 2.7 to 3.4r; aboral paxillae large, tabulate; marginal paxillae prominent; superomarginals smaller than inferomarginals, opposite to the latter; interradial areas very small; furrow series with 3 to 4 long spines; subambulacral series with 5 to 7 long bristling spines in a straight series.

Description. Eight specimens examined, measuring from 32 mm to 174 mm in R. The description was already given by the writer ('39) as follows:

Disc moderately large, rays ten or eleven in number. Aboral paxillae more distinctly spaced than in *endeca*. Paxillae large, tabulate in form, roundish or elliptical in contour, those on the disc being arranged irregularly, decreasing in size toward the sides and

end of ray, where they are comparatively small and arranged somewhat radially. The spinelets of paxillae are variable in number, depending on size; size, however, seems to vary in different localities. A specimen (123 mm in R) has, on large paxillae of disc, 14–16 peripheral and 5–7 central short spinelets so immersed in membrane that only the tips protrude. The summit of the group is flat and the central spinelets are generally shorter and smaller than the peripherals which are nearly equal in length. But in an example obtained from Yoiti, one of the central spinelets of the paxillae is the largest, protruding from the spinelets-group in the proximal portion of ray and disc. Aboral skeleton composed of irregular 3– or 4–lobed plates and the connecting ossicles. Papulae numerous in the meshes of the skeleton, five to ten or more in each papular area, gradually decreasing in number toward the distal and lateral portions of ray, but a large specimen (R 74 m) has twenty or even more papulae for an area on the disc.

Marginal plates numerous, larger than in *endeca*. Supermarginals opposite to the inferomarginals and exceedingly smaller than the latter, occasionally alternating with each other in the distal portion of ray. They are similar in form to the adjacent aborals, but in size larger than the latter, each with about 15–20 spinelets. Inferomarginals transversely oblong and with 20–25 or even more subequal spinelets.

Oral interradial areas very small, each containing about 20 plates; each plate with 5–12 spinelets longer than those of aboral paxillae.

Adambulacral spines long and bristling. The furrows are long, tapering, skin-covered, united by a web, mostly three or four in number, proximally four or five, distally three or two. Subambulacral comb straight, composed of five to seven stout, bluntly pointed membrane-sheathed spines, and the outermost one is shorter and slender. Mouth plates broader than in *endeca*, oral spines 8–9 in number, the inner two being long and stout, then gradually decreasing in length toward the distal end. Suboral spines in a row, 3–4 in number, the inner one being longest.

Madreporite conspicuous, situated midway between the margin and the centre of disc, bearing several paxillae around the margin.

Young specimen. A specimen (R. 32 mm) was examined. Aboral paxillae closely crowded, not so distinctly spaced as in large

specimens, each bearing 12–16 spinelets. Marginal plates low, not so prominent as in adult specimens, but arranged in two series. Superomarginals opposite to the inferomarginals, about one-half the size of the latter, and larger than the adjacent aborals. Superomarginals with 8–10 spinelets and inferomarginals with 12–16 spinelets. Oral interradial areas very small, paxillae with 5–6 spinelets. Subambulacral combs each composed of 4–5 spines in a straight series, and furrow spines 3 or 4 (distally 2) in number. Mouth plates, with 8 oral and 6 suboral spines in a series. Madreporite small, situated midway between the centre of disc and the margin.

Localities. Kamoi Misaki (Albatross station, 4987), Osyoro, Yoiti, Cape Tsiuka (Albatross station 4807, 4808), Yellow Sea; depth ranging from 44 to 80 fathoms.

Distribution. Monterey Bay to the Aleutian Islands, thence to the Kurile Islands and Japanese coasts to Yellow Sea.

Solaster dawsoni var. *intermedius* HAYASHI

Solaster dawsoni var. *intermedius*: HAYASHI, 1939, p. 302, pl. 24, figs. 9, 10.

Diagnosis. Differing from *dawsoni* in having much smaller aboral paxillae. Rays 10 in number, R about 2.9r; furrow series with 2 to 3 long spines; subambulacral series with 5 to 6 stout spines in a straight series.

Description. A single specimen was examined, measuring 83 mm in R, 29 mm in r. The description was already given by the writer ('39) as follows:

Aboral paxillae small, numerous, and in the central area of disc more widely spaced and a little larger than those on the periphery of disc and rays. Paxillae on the sides of ray smaller than those in the central portion, and arranged in more or less in longiseries. Large paxillae with ten to fifteen small, subequal spinelets. Aboral plates small, crowded, irregular in form.

Inferomarginals relatively large, prominent, strongly compressed, similar to those of *dawsoni,* but a little lower than the latter, each bearing about 35–40 spinelets in three transverse series. Superomarginals opposite to the inferomarginals, small, about as large as the adjacent aboral paxillae.

Oral interradial areas very small as in *dawsoni,* paxillae with

a little longer spinelets than in the aborals, about 10 or more in number.

The armature of adambulacral plates is similar to that of *dawsoni*. Furrow spines relatively long, mostly two in number, when three present, the adoral one being smaller. Subambulacral comb straight, composed of five or six spines, occasionally four. Mouth plates each with seven or eight graded stout oral spines, suboral spines seven or eight in one or two series.

Madreporite small, surrounded by several paxillae, situated about midway between the centre and the margin of disc.

Locality. Off Miyako.

Distribution. Only known from off Miyako, Japan.

Solaster paxillatus SLADEN

Solaster paxillatus: SLADEN, 1889, p. 452, pl. 71, figs. 1–3, pl. 72, figs. 1, 2; FISHER, 1911, p. 315, pl. 87, figs. 1, 2, pl. 113, fig. 3; HAYASHI, 1939, p. 303, pl. 24, figs. 5, 6.

Diagnosis. Disc moderately large, rays stout, 9 in number; aboral paxillae fairly closely set, with some indication of interradial streaks free from paxillae; aboral paxillae fairly closely set, subtabulate with numerous small spinelets. Inferomarginal paxillae prominent with numerous small spinelets; superomarginals much smaller, but larger than adjacent aborals, alternating with inferomarginals; furrow series with 5 or 6 slender spines, the middle ones longer than the laterals; subambulacral series with 5 or 6 long spines in a curved series.

Description. Six specimens were examined, measuring 36 mm to 76 mm in R, R ranging from 2.2 to 4r. The description was already given by the writer ('39) as follows:

Disc not so elevated as in *S. Uchidai,* rays narrower and longer than those of the latter species, but in some specimens rays considerably broad at the base. Interradial streaks more or less free from paxillae as in *borealis* and *Uchidai,* but not usually. Aboral paxillae numerous, small, low, closely set, not so widely spaced as in *Uchidai.* The paxillae are immersed in membrane, subtabulate with a roundish crown of small slender spinelets, numbering 15–30.

On the peripheral half of disc and rays the paxillae are arranged in very oblique transverse rows, but the longitudinal arrangement is not evident. Aboral plates along lateral sides of ray regularly four-lobed, imbricating each other. The meshes each contain mostly one or two papulae, not several as in *borealis*. No isolated ossicles in the mesh.

Marginal plates in two series and of very unequal, the superomarginals alternating with the inferomarginals. Superomarginals considerably larger than the adjacent aboral paxillae. Inferomarginals large, paxilliform, lower and more numerous than in *borealis*, bearing a large number of short skin-covered spinelets which each stand on a very compressed fan-shaped pedicel with a curved outer summit. The spinelets in the inner end are large and in two series, then rapidly decrease in length toward the outer end, where they are disposed in three or four series and equal in size to the spinelets of superomarginal paxillae.

Oral interradial areas larger than in *borealis*, with spaced low paxillae bearing short slender spinelets numbering about four to ten or more. A series of small intermediate plates bearing one to several spinelets extends over half the length of ray.

Furrow spines short, slender, webbed at the base, five or six in number near the mouth, then four along the greater part of ray, then reduced to two or three in the distal part. Subambulacral spines long and stout, webbed at the base, arranged in a transverse series curved aborad, five or six in number at the base of ray, then reducing in number toward the arm tip. These spines are slenderer than in *borealis*. Mouth plates slightly narrower than those of *borealis*, with nine to ten webbed oral spines, the two or three innermost being longer than the rest. Suboral spines membrane-sheathed, numbering ten or more; the four or five adoral in a lineal series being longer and stouter than the outers in two or three series.

Madreporite fairly large, situated about midway between the margin and the centre of disc, surrounded by several paxillae.

Localities. Ukijima, Numa, Misaki and Omai Saki (Albatross station 5055); depth ranging from 124 to 350 fathoms.

Distribution. From the northern Pacific coast of Honsyu, Japan to Bering Sea, thence to the vicinity of Kadiak Islands, Alaska.

Solaster borealis (FISHER)

Crossaster borealis: FISHER, 1906, p. 134.
Solaster borealis: FISHER, 1911, p. 320, pl. 91, figs. 1–3, pl. 92, figs. 1, 2, pl. 113, figs. 2, 2a; HAYASHI, 1939, p. 305, pl. 24, figs. 1, 2.

Diagnosis. Rays 10 to 12 in number; aboral paxillae small, spaced; bare interradial streaks well marked; superomarginal paxillae indistinguishable; inferomarginal plates prominent, well spaced, with 7 to 10 spinelets in a series; interradial areas small; furrow series with 3 to 5 short spinelets; subambulacral series with 3 or 4 long spines in a curved series.

Description. Three specimens were examined, measuring from 59 mm to 123 mm in R, R ranging from 2.8 to 3.2r. The description was already given by the writer ('39) as follows:

Aboral integument covering skeleton and paxillae. Paxillae small, spaced, numerous, each with a low tablum surmounted by one to six (mostly one to four) slender, tapering spinelets. Papulae prominent, numerous, one to seven (mostly three or four) in each area. The bare interradial streaks are well marked. Aboral skeleton forming meshes composed of three or four-lobed plates and rod-like, connecting ossicles (not numerous). One or two isolated ossicles are existing mostly in the meshes of disc and arm base.

Superomaginal plates indistinguishable from the adjacent aboral paxillae. Inferomarginal plates very prominent, well spaced, 20 to 23 on each side of ray, with fairly high pedicels each bearing a transverse series of seven to ten stout tapering pointed skin-covered spines, and occasionally one or two small spines stand adorally out of the series.

Oral interradial area rather small. The plates are small, irregularly arranged in rows, each bearing one or two small skin-covered spinelets. The plates adjoining adambulacral plates extend beyond three-fourth the length of ray.

Adambulacral plates each armed with three or four (proximally five, distally two), slender, tapering skin-covered furrow spines which are united together for about half their length by a web, the laterals being shorter. Subambulacral comb composed of three or four much longer, stouter skin-covered spines in a transverse series. Mouth plates each with a webbed series of ten or eleven oral spines, and on the surface of the plate near the inner end there is a stout

spine, sometimes appended by one or two accessory spinelets, but suboral spines being occasionally entirely absent.

Madreporite exposed, small, situated at the inner end of an interradial streak.

Localities. off Miyako, off Otiisisaki (Albatross, station 5044), Urakawa (Albatross station, 5038); depth ranging from 175 to 309 fathoms.

Distribution. From off San Diego, California, to Bering Sea, thence to Hokkaido and northern Honsyu, Japan.

Solaster Uchidai HAYASHI

Solaster Uchidai: HAYASHI, 1939, p. 306, pl. 24, figs. 3, 4.

Diagnosis. Resembling *borealis* and *paxillatus*: Disc large, rays 10 to 12 in number; aboral paxillae large, widely spaced on disc; bare interradial streaks marked; marginal paxillae in two series; superomarginals much smaller than inferomarginals, alternating with them; interradial areas small; furrow series with 5 (3 to 7) subequal short spinelets; subambulacral series with 5 (3, 4) stout long spines in a curved series.

Description. Five specimens were examined, measuring 56 mm to 90 mm in R, R ranging from 2.5 to 2.8r. The description was already given by the writer ('39) as follows:

Disc large, swollen, elevated, rays swollen aborally, relatively short, gradually tapering, ten or eleven in number, R ranging from 2.5 to 2.8r. Interradial streaks present, but not so well marked and free from paxillae as in *borealis*. Aboral paxillae fairly large, widely spaced, with ten to twenty small, nearly equal short spinelets heavily invested with integument. They gradually decrease in size toward the arm tip. The paxillae on the disc are irregularly arranged, more widely spaced and larger than those on rays, where paxillae are arranged more or less in longiseries. Aboral plates with 3, 4, or 5 irregular lobes, each plate imbricating with each other; regular meshes thus being formed in the rays. Papulae mostly single, occasionally two and on the disc one to five pores in a papular area.

Marginal plates in two series, superomarginals alternating with inferomarginals as in *paxillatus*. Superomarginals much smaller than the inferomarginals and nearly equal to the adjacent aborals.

Inferomarginals prominent, resembling those of *borealis*, but more numerous and lower than the latter, numbering 22–25 along the side of a ray (R 56 mm). Pedicels much compressed, each with 7–11 short, skin-covered spines arranged in a curved series.

Oral interradial areas smaller than in *paxillatus*, with spaced low paxillae thickly covered by integument, bearing several slender spinelets which decrease in number toward the arm tip. Plates arranged irregularly in rows, the innermost series extending beyond two-third the length of ray.

Adambulacral plates wider than long, separated by more than their own width. Furrow spines covered with skin, short and slender, mostly five in number (proximally 6–7 and distally 3–4). Subambulacral comb slightly curved aborad, composed of stout long membrane-sheathed spines, the outermost one being shortest, mostly five in number, three or four in the distal portion of ray. Mouth plate similar to those of *borealis*, with 10–11 oral spines, three adoral longer and stouter than the rest. Suboral spines situated near the end of plate, one to five in number, arranged in a series, but rarely absent. The most adoral one is stout and long.

Madreporite small, situated about halfway between the margin of disc and the centre, surrounded and partly obscured by 5–6 large paxillae.

Localities. Off Kinkasan (Albatross station, 5047), off Jyogasima (Albatross station 5091), North Pacific coast of Honsyu; depth ranging from 107 to 197 fathoms.

Distribution. North Pacific coast of Honsyu.

Genus *Crossaster* MÜLLER & TROSCHEL

Crossaster: MÜLLER & TROSCHEL, 1840, p. 103. Type, *Asterias papposa* LINNÉ; VERRILL, 1914, p. 258; FISHER, 1919, p. 447.

Key to Japanese species of *Crossaster*

Rays 9 to 11; paxillae prominent, pencillate, spaced.

a¹. Rays 9 to 11, R 2 to 2.6; marginal paxillae very prominent, widely spaced; furrow spines 3 to 6 (mostly 4–5). ..... ***papposus***

a². Rays generally 10, R 2.3 to 2.8; marginal paxillae more numerous, less prominent; furrow spines 4 to 7 (mostly 5–6); adambulacral armature more thickly covered with skin. ..... ***japonicus***

Crossaster papposus (LINNÉ)

Crossaster papposus: VERRILL, 1914, p. 252, pl. 5, fig. 2, pl. 8, figs. 1, 2, pl. 9, fig. 4, pl. 49, fig. 4; HAYASHI, 1939, p. 308, pl. 23, figs. 3, 4.
Solaster papposus: FISHER, 1911, p. 325, pl. 94, figs. 1–6.

Diagnosis. Rays 9 to 11, R 2 to 2.6r; paxillae prominent, pencillate, with many slender spinelets longer than pedicels; marginal paxillae very prominent, widely spaced; ventrolateral areas small; furrow series with 3 to 6 spinelets; subambulacral series with 6 to 8 spinelets.

Description. The writer examined specimens measuring from 30 to 57 mm in R, R ranging from 2 to 2.6r. The description was already given by him ('39) as follows:

Disc large, a little swollen, oral side subflattened. Rays relatively short, gradually tapering, variable in number, commonly ten or eleven, rarely nine.

The description of one example (R 30 mm) is as follows:

Aboral skeleton forming a widely open reticular structure with pencillate paxillae widely spaced. Intervening papulae numerous, one to ten or even more in an area, according to the size of papular areas. Paxillae each with a short, stout pedicel and many slender spinelets increasing in length from the periphery of pedicel to the centre. Spinelets longer than the pedicel. The spinulation of paxillae is considerably variable in examples. Carinal paxillae not distinctly prominent, but some of them being a little larger than the others.

Marginal paxillae prominent, usually well spaced by more than their own width, numbering eight to eleven on the side of a ray. Marginals resembling in form the aborals but sometimes transversely elongated, occasionally proximal two or three much compressed into fan-shape. Spinelets long and slender, not decidedly shorter than the subambulacral spines in a comb. Oral interradial area small with one or two small paxillae.

Furrow spines composed of five slender webbed spinelets, the adoral one being smaller than the others. The transverse subambulacral comb consists of six to eight tapering stouter spines. The inner end of the comb curves aborad. Mouth plates with 11–12 oral spines, five adorals being longer and stouter than the others,

and just behind the series are found five or six stouter suboral spines in a series.

Madreporite small, situated about midway between the centre and the margin of disc.

Localities. Onagawa; Kamoi-Misaki (Albatross station, 4987), Bomosiri sima (Albatross station, 4993); Toyama Bay; off Miyako; depth 59 to 142 fathoms.

Distribution. Circumpolar: North Pacific and Atlantic Oceans; on Asiatic coast to Okhotsk Sea, Japan Sea and North Pacific coast of Honsyu, Japan.

Crossaster papposus forma ***japonicus*** FISHER

Solaster japonicus: FISHER, 1911, p. 329, pl. 95, figs. 1, 2, pl. 113, fig. 4.
Crossaster papposus (part): HAYASHI, 1939, p. 309, pl. 23, figs. 1, 2.

Diagnosis. Differing from *papposus* in having more numerous less prominent paxillae; the ratio of R:r being slightly larger; adambulacral armature more thickly covered with skin; furrow series with 4 to 7 spines (mostly 5–6); rays generally 10.

The writer examined 24 specimens of the species, all obtained from the Japan Sea, measuring 35 mm to 94 mm in R, R ranging from 2.3 to 2.8r. The writer described about the species in his previous paper ('39).

In some specimens the margin plates show more or less the intermediate appearance between two forms, *papposus* and *japonicus*.

Localities. Off Sado Id. (Albatross Station 1814); Hime Saki (station 4819), Benkei Misaki (station 4981), Sawa Saki (station, 4820), Bomasiri Sima (station, 4991, 4992).

Distribution. Northern part of Honsyu and Hokkaido.

Family Pterastridae PERRIER, 1875

A good idea of the group was given by Fisher ('11). Spinulosa with a nidamental cavity, opening centrally by an osculum; ventrolateral spines usually present, supported by a ventrolateral web; without ventrolateral intermediate plates; external to adambulacral plates, a series of segmental aperture guarded by a specialized opercular spinelet or papilla; mouth plates large broad, plowshare-shaped; membraneous interradial septa.

Key to Japanese Genera of Pterasteridae

a^1. Adambulacral spines united by a web, forming transverse combs; supradorsal membrane with muscular fibrous bands; tube-feet in two or four rows.
- b^1. Adambulacral combs of one kind; muscular bands in supradorsal membrane not regularly reticulated; sometimes spicules in membrane; tube-feet in 2 or 4 rows. ..... ***Pteraster*** M. & TR.
- b^2. Adambulacral combs of two kinds; less prominent alternating with more prominent ones; muscular bands regularly reticulated; no spicules in membrane; tube-feet in four rows, at least proximally..... ***Diplopteraster*** VERRILL

a^2. Adambulacral armature not forming transverse webbed combs; spinelets free; ventrolateral spines long, projecting beyond border of ray; tube-feet in two rows. ..... ***Hymenaster*** THOMSON

Genus *Pteraster* MÜLLER & TROSCHEL

Pteraster: MÜLLER & TROSCHEL, 1842, p. 128; FISHER, 1911, p. 344.

Key to the Japanese Species of *Pteraster*

a^1. Rays usually five.
- b^1. Tube-feet in two rows; adambulacral spines in a web.
  - c^1. Oral spines free, not webbed, supradorsal membrane rather thin; spiracula abundant; ventrolateral membrane narrow; adambulacral spines 6 (5–7), the first two very flat and truncate; a very conspicuous triangular suboral spines; R 1.4r. ..... ***obesus***
  - c^2. Oral spines independently webbed; supradorsal membrane thin; spiracula few; ventrolateral membrane narrow; adambulacral spines 5 or 6; oral spines 5; suboral spine prominent, three edged, hyaline; R 1.7 to 1.9r. ..... ***uragaensis***
  - c^3. Oral spines of each angle united by a common membrane; body high; spiracula numerous; ventrolateral membrane very narrow.
    - d^1. Supradorsal membrane thin; paxillae with 8–10 spinelets; adambulacral spines 5 or 6; oral spines 5 to 7; a heavy suboral spine; R 1.6r. ..... ***multiporus***
    - d^2. Supradorsal membrane thick; paxillae with about 20 spinelets; adambulacral spines 5 to 7; oral spines 5 to 7; a heavy suboral spine; R 1.6 to 2.3r. ..... ***tesselatus***
    - d^3. Supradorsal membrane thicker; paxillae with 8 spinelets; adambulacral spines 5 to 7; oral spines 7; a heavy suboral spine; R 1.2r. ..... ***glomus***
- b^2. Tube-feet in four series, at least proximally.
  - c^1. Oral spines of each series independently webbed; adambulacral spines 4 to 5; oral spines 5; a suboral spine; paxillae with 3 (2) long spines; R 2r. ..... ***jordani***
  - c^2. Oral spines 6 to 7; adambulacral spines 4 to 5; paxillae with 1 to 3 central and 7–9 peripheral horizontal spines; R 1.7 to 1.8r. ***japonicus***

a^2. Rays six to nine; supradorsal membrane tough, spiny appearance; numerous spiracula; ventrolateral membrane broad; adambulacral spines 4 to 5; oral spines 5; two series united by a common membrane; R 1.3 to 1.6r... ***obscurus***

Pteraster obesus CLARK

Pteraster obesus: CLARK, 1908, p. 283.

The species has been known only from Sagami Bay. No specimens examined. The original discription is as follows:

"Rays 5. R = 22 mm., r = 16 mm., R =1.4r. Breadth of ray at base, 16 mm. Interbrachial arcs shallow. Disc high, vertical diameter, 16 mm; rays not clearly marked off. Abactinal surface of rays high, rounded; actinal surface somewhat flat. Distal end of ray upturned, so that ambulacral furrows terminate on abactinal surface. Supradorsal membrane rather thin with no sign of reticulations. Spiracula small but very abundant all over abactinal surface. Paxillae high with numerous spines (8–10 or more) of approximately equal size. About 30 of the paxillae have the spines longer and stouter than the others, and these push the membrane up into more or less conspicuous points or ridges, which are irregularly scattered and give the abactinal surface a rough, almost warty appearance. Apparently there are no other calcareous particles in the membrane. Osculum large, surrounded by about 50 closely webbed long spines, which nearly close it. Ambulacra of moderate width; feet in two rows. Adambulacral plates, each with six (near the mouth there may be seven) spines, the innermost much the smallest, the outermost longest; as the innermost is situated on the inner aboral corner of the plate and the others are on its adoral side, the series is distinctly curved, with the concavity away from the mouth; all the spines are united to each other and to the actino-lateral spine by a membrane which reaches nearly to their free ends, but from which they project distinctly. Actino-lateral spines short, only about half as long again as the outermost adambulacral spine; as they are approximately equal except at tip of ray, the actino-lateral "fringe" is narrow and nearly parallel-sided, and is thus completely concealed from above; aperture-papilla small, free only along its aboral edge. Mouth-plates large, decidedly elevated at their aboral ends, where they terminate in a conspicuous point; the points of the adjacent plates are closely appressed, so there is only one point for the two

plates. Each plate bears on its margin 5–7 (usually 6) spines, of which the first is about as long as the plate, flat, about one-fourth as wide as long, and square-cut at the end; the second is about two-thirds as long and, although flat, is somewhat more tapering; the remaining 3–5 spines are very slender, pointed, and about half as long as the first; the spines are all free, no membrane being developed between them. On the surface of each mouth-plate, at about the centre, is a very conspicuous superoral spine; it is longer and much stouter than the first mouth-spine, and terminates in a heavy, sharp, triangular point.—Color of alcoholic specimen, purplish pink, lightest on the ambulacra.

I specimen from Sagami Bay, Japan; 35° N. X 138° 48′ E., 75 fathoms. Owston collection."

Pteraster multiporus CLARK

Pteraster multiporus: CLARK, 1908, p. 284.

The species was not represented in any collection at the writer's hand. The original description is as follows:

Rays 5. R=16 mm., r=10 mm., R=1.6r. Breadth of ray at base 11 mm. Interbrachial arcs rather deep and angular. Disc moderately high, vertical diameter 8.5 mm.; rays not well marked off. Abactinal surface of rays rather high, rounded; actinal surface flat. Distal end of ray upturned so that ambulacral furrows terminate on abactinal surface. Supradorsal membrane thin, very indistinctly reticulated. Spiracula small but exceedingly numerous all over the abactinal surface. Paxillae low, with numerous spines (8–10 or more), which are much longer than the stalk that bears them; these spines are slender and approximately equal, so that the entire abactinal surface is relatively smooth. Aside from the tips of these spines there do not appear to be any calcareous particles in supradorsal membrane. Osculum rather small, surrounded by 30–40 rather short, closely webbed spines. Ambulacra rather narrow; feet in two rows. Adambulacral plates each with five (sometimes six) spines, the innermost much the smallest, the outermost longest; as the innermost is situated on the inner aboral corner of the plate and the others are on its adoral side, the seires is distinctly curved, with the concavity away from the mouth; all the spines are united

to each other and to the actino-lateral spine by a membrane which reaches nearly to their free ends, but from which they project distinctly. Actino-lateral spines short, little longer than outermost adambulacral spine, flattened and widened at the bluntly-rounded tip; they are subequal and the actino-lateral "fringe" is accordingly narrow and nearly parallel-sided. Aperture-papilla small, free only along aboral edge. Mouth-plates moderate, each with six slender, nearly cylindrical but pointed spines along the margin, the innermost largest, outermost smallest; the entire group of twelve spines is completely united by a thin but conspicuous membrane; superoral spines moderately stout, cylindrical but pointed, slightly exceeding the longest oral spines.—Color of alcoholic specimen, purplish pink.

I specimen from Sagami Bay, Japan; 35° N. X 138° 48′ E., 75 fathoms. Owston collection. Although taken at the same station with *obesus*, it is an entirely distinct species. It is closely allied to *reticulatus* from the Hawaiian Islands, but differs in having webbed oral spines, short, broad, actino-lateral spines, and low paxillae.

Pteraster tesselatus IVES

Pteraster tesselatus: FISHER, 1911, p. 359, pl. 95, figs. 1–5; VERRILL, 1914, p. 268, pl. 32, figs. 1, 2, pl. 86, figs. 4–4c, pl. 94, fig. 1; HAYASHI, 1938, p. 288, pl. 2, figs. 7, 8.

Diagnosis. General form broadly stellate, R 1.6 to 2.3r. Disc high, rays five, short and thick, with swollen sides; supradorsal membrane thick, spongy; no deposite of spicules; spiracula numerous; paxillar spinelets about 20; ventrolateral membrane narrow; adambulacral combs with 5 or 6 (7) spines; mouth plate with 5–7 spines; both series united by a continuous membrane; a heavy suboral spine.

The measurements are as follows:

R	r	R:r	Locality	Depth	Collection	Station
28mm	18mm	1.6	Misaki	300 fms	Goto	——
45mm	22mm	2	Misaki	——	Goto	——
50mm	26mm	1.9	Misaki	——	Goto	——
51mm	22mm	2.3	Misaki	——	Goto	——
54mm	28mm	1.9	Seto	——	Seto M. B. L.	——
61mm	39mm.	1.6	Korsokov, Saghalin	21 fms	Albatross, 1906	5010
64–72mm	30mm	2.1–2.4	Misaki	——	Goto	——
60–74mm	36mm	1.7–2.1	Misaki	——	Goto	——

Description. The writer ('38) already gave the description of the species as follows:

Body resembling a stellate cushion; disc large, swollen, rays wide, short, thick, with recurved blunt tips, nearly elliptical in cross section, five in number.

Supradorsal membrane thick, tough, spongy. The surface is smooth, but in poorly preserved specimens is more or less papillated by paxillar spines. No spicules in supradorsal membrarne. Pseudopaxillae very numerous, with about 20 spines in a group. These spines are immersed in seven or eight laminae of membrane radiating from the centre of the group. The spines peripherally radiated are slightly stouter than those in the centre of the group. The pedicel is rather shorter than the spines or nearly equal in length to the latter, the former measuring about 1.7 mm–2 mm in length, the latter about 1.8 mm–2.7 mm. The laminae are joined with the inner side of the supradorsal membrane, showing an appearance of "a groined vault in miniature." Numerous minute spiracula scattered all over the supradorsal surface. Osculum conspicuous, elevated, surrounded by five large radial paxillae. Dorsal membrane extended well into the under side, making the thick and swollen margin of body. Ambulacra narrow, and tube-feet arranged in two rows. Adambulacral comb consisted of five or six (occasionally seven) webbed spines, the one or two inner being short, the rest long and nearly subequal in length. The outer-most one is united with the ventrolateral spine by a narrow membrane. Mouth plate have each five to seven furrow spines, the innermost one being the longest, then gradually decreasing in length. The paired spines (10–14) in each angle are united by a common mebrane. Suboral spines, one for each plate, pointed, sheathed in membrane, cylindrical in form, much heavier and longer than other spines. Ventrolateral spines short and stout, a little flattened, enlarged distally and about same in length as long adambulacral spines, so the ventrolateral membrane is narrow, and the supradorsal membrane extends well into the actinal surface. There is no free edge or fringe except for the tip of ray. Ventrolateral spiracles narrow, elongated slit in form, situated at the base of ventrolateral mebrane between the spines, each spiracle with a very small calcareous valve. Madreporite convex, as high as wide, situated near the centre of disc.

The coloration of the sea-star is variable, purplish, brownish

or reddish in life, according to Mr. F. Hiro. The alcoholic specimens have blackish or bluish mottled patterns.

Localities. Seto, Misaki, Saghalin (Albatross station 5010).

Distribution. Known from the Bearing Sea southwards along the North American coasts to Washington and also along Japanese coasts to Saghalin and Honsyu (Misaki and Seto).

Pteraster tesselatus glomus n. subsp.

(Pl. 11, figs. 1, 2.)

A large specimen was examined, which measures 70 mm in R, 57 mm in r. The body is much more soft and spongy as in *tesselatus* and is very thick, about 50 mm high, so it gives more or less a globular appearance.

It resembles *Pteraster tesselatus arcuatus* in having pentagonal body and supradorsal membrane with numerous discontinuous creases, but differ from it in having fewer spinelets in paxillae. From the type species it differs in having much thicker, soft pentagonal body and supradorsal membrane with fine creases. Concerning the affinity of the present species to *P. multiporus*, the writer can not give any conclusion, because *multiporus* reported by Clark from Sagami Bay is based on very small specimens (only 16 mm in R) with a thin supradorsal membrane.

Diagnosis. Body nearly pentagonal form, very thick, rather soft, mouth region deeply sunken; R 1.2r; supradorsal membrane very thick, spongy; no deposits of calcareous matter; spiracula very numerous in fine discontinuous creases; paxillae with 8 spinelets, subequal in length to pedicel; ventrolateral membrane very narrow; adambulacral spines 5 to 7; oral spines 7; a heavy suboral spine.

Description. Supradorsal membrane, thick, tough, spongy, rather soft; no calcareous deposits. The membrane extends well into the oral side as in *tesselatus*. Spiracula fine, very numerous situated in numerous fine discontinuous creases on supradorsal membrane. Paxillae about 13 mm long at about middle of R; pedicels subequal to in length or a little shorter than the spines. The spines are slender, expanded, 8 in number, each immersed in a tough lamella. No spines protruding the supradorsal membrane.

Adambulacral plates each with 7 spines in a thick web, 5 distally. The inner two are usually smaller than the outers which are about

same in size. Mouth plates with 7 oral spines, the first spine being longest, the second a little shorter, then rapidly decreasing in length. The oral spines of two series are united by a common membrane; suboral spines single, stout, cylindrical, but shorter than the first oral spine.

Ventrolateral membrane very thick and narrow; the spines never extend twice as long as oral spines, generally subequal to or a little longer than them. Ventrolateral aperture narrow and oblong.

Locality. Sengenzuka (Misaki), 400 fathoms in depth.

Pteraster uragaensis n. sp.

(Pl. 11, figs. 3, 4.)

Two specimens examined have oral spines united by a web in each and sharp three edged suboral spines. They are closely related to *Pteraster trigonodon,* but differ in paxillae having low pedicels; in supradorsal membrane being devoid of spicules, fewer spiracula. It seems to be a new form of *Pteraster.*

The measurements and locality are as follows:

R	r	R:r	Locality	Depth	Collection	Station
28mm	15mm	1.9	Jyogasima, Uraga Strait	197 fms	Albatross, 1906	5091–*Type*
20mm	12mm	1.7	Jyogasima, Uraga Strait	197 fms	Albatross, 1906	5091

Diagnosis. Rays five, form stellato-pentagonal, R 1.7 to 1.9r. Supradorsal membrane thin, bristling with paxillar spines; no regular reticulation of muscle fibres; no deposits of calcareous matter; spiracula few; adambulacral spines 5 or 6 in a web; oral spines 5, two series not in a common membrane; suboral spines prominent, with three edged, sharply pointed; ventrolateral membrane narrow.

Description. Form stellato-pentagonal, disc swollen, 14 mm high, oral side flattened. Supradorsal mebrane thin, tough, bristling with paxillar spinelets. Paxillae with low pedicels about 1 mm long and the spines are long and slender, 4 or 5 in number, about 2.5 mm in length. Spiracula very small, few, and almost invisible. Supradorsal membrane without deposits of spicules and regular reticulation of muscle fibres.

Adambulacral plates each with 5 or 6 spines thickly webbed, the innermost one being usually smaller than the rest which are nearly

equal in length. The webs extend to the free margin of lateral membrane. Mouth plates each with 5 graduated spines in a web; two series of the spines not in a continuous membrane. Suboral spines single, large, sharp, pointed, glassy, three edged with three concave faces. Tube-feet in two rows. Aperture paxilla prominent with free aboral edge.

Ventrolateral membrane rather narrow, with narrow free border. Spines gradually decreasing in length, proximally about twice as long as outer adambulacral spines.

Locality. Jyogasima, Uraga Strait, 197 fathoms in depth.

Pteraster jordani FISHER

(Pl. 11, fig. 8, Pl. 12, fig. 2.)

Pteraster jordani: FISHER, 1905, p. 314; ——, 1910, p. 67; CLARK, 1908, p. 286; FISHER, 1911, p. 350, pl. 100, fig. 2, Pl. 101, fig. 1, Pl. 117, figs. 1, 1a–b.

A single specimen was examined, measuring 65–70 mm in R, 31 mm in r. The specimen is similar to *P. marsippus* in paxillae and adambulacral armature but especially resembles *P. jordani* in having no deposits of spicules in supradorsal membrane and in aperture papillae. Distinction from *japonicus* lies in number of paxillar spines.

Diagnosis. Rays five, stellate form, R about 2r; supradorsal membrane rather thin; no calcareous deposits; paxillae with short pedicels surmounted by 3 (2) long spines; spiracula not numerous. Adambulacral plates with 4 or 5 webbed spines; oral spines 5 in a web; a suboral spine; tube-feet more or less in four rows; ventrolateral membrane narrow.

Description. Supradorsal membrane rather thin; no deposits of calcareous matter. Paxillae each with a low pedicel. Three rarely two long spines joined together by a muscular band as in *marsippus*. In the middle of ray, the spines are 5 to 6 mm long, one of them being generally slender than the other two. Pedicels about 0.8 to 1 mm high. Spiracula not numerous, 2 to 5 around a paxilla. Fine crisscrossing muscule fibres exceedingly abundant, the summit of the paxillar spines being connected by faint muscular bands.

Adambulacral combs each with 5 or 4 long and slender subequal spines; the combs extending outward to the middle of ventrolateral

membrane. The innermost spines are occasionally shorter than the outers. Mouth plates each with 5 oral spines in a web, rapidly decreasing in length; a long suboral spine located behind the innermost spine, which is nearly same as long as the latter. Tube-feet in four series, but not so well represented as in *Diplopteraster*. Aperture papillae, prominent jawbone-shaped, free on the aboral margin. The aperture papilla is not tended over by a membrane as in *marsippus*.

Ventrolateral membrane narrow, wide at the base, rather thin forming a lateral fringe, free from supradorsal membrane for one-third or one-fourth of its wide.

Locality. Sio-Misaki, 712 fathoms, Albatross, 1906, station, 4975.

Distribution. Known from lower California to Washington; and Sio-Misaki, Japan.

Remarks. Concerning two related *Pterasters, jordani* and *marsippus,* Fisher ('11 p. 253) describes as follows: *marsippus* "is evidently a northern representative of *Pteraster jordani*". The Japanese specimen examined by the writer somewhat indicates an intermediate form between the two species.

Pteraster japonicus UCHIDA

Pteraster japonicus: UCHIDA, 1931, p. 77, 4 figs.

The present species was not represented in the collections examined by the writer. The original description is as follows:

Die neu aufgefundene Art weist grosse Ähnlichkeit mit der von Prof. Fisher beschriebenen *Pteraster tessellatus* aus dem nordpazifischen Ozean auf. Sie unterscheidet sich aber von letzterer durch die weichere Abactinalseite, die etwas hervorragenden Paxillen und besonders durch die besser entwickelte Membran auf dem Actinolateralkamm.

Beide Exemplare haben 5 Arme. Die Ausmasse sind wie folgt; Exemplar A: R=35 mm, r=19 mm, Armbreite an der Basis=23 mm. Exemplar B: R=45 mm, r=27 mm, Armbreite an der Basis=30 mm. Die Arme mit den etwas nach aussen gebogenen Seiten und der nach der Rückenseite zurückgebogenen stumpfen Spitze sind verhältnismässig kurz und verengen sich allmählich zur Spitze. Die inter-

brachialen Räume sind breit und seicht. Die Rückenseite, besonders in der Scheibe, zeigt eine kissenförmige Wölbung, während die Actinalseite fast flach ist. Die Rückenseite bedeckt eine weiche, dicke, schwammartige Membran mit vielen Papillen und mehreren kleinen, netzartig verstreuten Stacheln, die besonders in der Nähe der Armspitze auffallen und mehrere eigenartige Paxillen bilden. Die Paxillen bestehen aus 1–3 Stacheln, die nach den Spitzen hin zusammenlaufen und so einen auf der Oberflächesenkrecht stehenden Fortsatz bilden, sodann aus 7–9 Stacheln, die radial um die Basis der senkrechten kleinen Stacheln geordnet sind und horizontal in der Membran liegen. Fast regelmässig ordnen sich die Paxillen parallel zu dem Arm an: 9 Reihen im Exemplar A und etwa 10 unregelmässige Reihen im Exemplar B. Die Paxillen in der Scheibe sind grösser als die in der Armspitze. Die Madreporenplatte ist schwer zu finden, da sie von einigen Paxillen dicht bedeckt ist; sie liegt in der interbrachialen Gegend zwischen Zentrum und Rand. Nicht gross, aber leicht bemerkbar ist das Osculum, das von einigen kennzeichnenden kleinen Stacheln umrahmt ist; ausserdem verläuft rings um den Rand eine breit ausgekehlte Furche. In die Ambulacralfurche sind die Ambulacralfüsse in etwa 2–3 Reihen beim Exemplar A, in etwa 3–4 Reihen beim Exemplar B eingeordnet. Der Adambulacralkamm, der gewöhnlich aus 4–5 kleinen, dicht zusammengedrängten Stacheln besteht, verläuft quer zur Achse des Armes. Zwischen jedem Stachel dehnt sich eine gut entwickelte Membran, die sich auch über diesen hinaus erstreckt und so 4–5 sackartige Fortsätze bildet. Die Actinolateral-Stacheln liegen unter der Membran und sind quer zum Arm angeordnet. Diese Stacheln sind verhältnismässig kurz an der Basis des Armes; in dessen Mitte sind sie länger. Alle Mundstacheln—ihre Zahl beträgt 6 bis 7—sind durch eine starke Membran verbunden, die sich bis zu 4–6 langen, sackförmigen Fortsätzen ausdehnt. Während im Exemplar A die Stacheln gegen den Rand zu kleiner werden, bleiben sie im Exemplar B in der Grösse fast gleich. Auf der Actinalseite ist der Armrand von einer dicken, flachen Membran bedeckt; die interbrachiale Gegend ist stachelfrei und besonders weich.—Die Farbe der beiden Exemplare in Alkohol ist dunkelpurpurgrau auf der Rückenseite und hellpurpurgrau auf der Actinalseite; die Ambulacralfüsse sind gelblichgrau.

Type-locality. North Pacific coast of Japan.

Pteraster obscurus (PERRIER)

(Pl. 12, figs. 4–6, pl. 13, fig. 4.)

Pteraster obscurus: FISHER, 1911, p. 363, pl. 105, figs. 1–4, pl. 106, figs. 1, 2.

Three specimens were examined, the measurements and localities being as follows:

Rays in number	R	r	R:r	Locality	Depth	Collection	Station
6	30mm	23mm	1.3	Cape Patience	75 fms	Albatross, 1906	5023
6	31mm	21mm	1.5	„	„	„	„
9	74mm	48mm	1.6	Tartary Gulf	318 fms	„	4997

Diagnosis. Rays 6 to 9, robust, short broad, ridged; R. 1.3 to 1.6r; supradorsal membrane tough, without spicules, with numerous spiracula; paxillae stout with 6 to 8 radiating peripheral spines and 4 to 6 slender central ones; supradorsal membrane showing a bristling appearance by the presence of peripheral spines; adambulacral spines 4 or 5, in a web; oral spines 5, two series united by a thick membrane; suboral spine one; ventrolateral membrane thick, wide, defining ambitus.

Description. Supradorsal membrane very tough, with muscle fibres, without regular reticulation. The surface is rather uniformly papillated with stout peripheral paxillar spines, showing a spiny appearance. Spiracula very numerous in creases of the skin. There are found smooth narrow interradial grooves, free from spiracula. In small specimens these areas are inconspicuous. Paxillae with rough tipped, radiating 6 to 8 peripheral spines, one of which is generally heavier and longer than the rest; and 4 to 6 central spines slender.

Adambulacral plates each with 4 to 5 spines, the inner one being much shorter than the outers, which are subequal in length and more or less compressed. These spines are thickly covered with a membrane. From the outermost spines thick membranes extend across the ventrolateral membrane. Mouth plates each with 5 spines, decreasing very rapidly in length from the inner to the outers; both series of the spines united by a continuous membrane. The large spines are considerably flattened; suboral spine stout, pointed, slightly shorter than the innermost oral spines. Aperture large, ovate, closed by an operculum.

Ventrolateral membrane tough, wide, transversed by continuations of adambulacral fans, defining ambitus. Ventrolateral spines truncate, flattened, hidden by a thick membrane.

Localities. Cape Patience, Saghalin and Tartary Gulf.

Distribution. Circumpolar; known the Atlantic; in the Pacific from Bering Sea to Japan.

Genus *Diplopteraster* VERRILL

Diplopteraster: VERRILL, 1880, p. 400; FISHER, 1911, p. 370.
Retaster (par): SLADEN 1889, p. 477.

Diplopteraster multipes (SARS)

(Pl. 12, fig. 1, pl. 13, fig. 1.)

Diplopteraster multipes: FISHER, 1911, p. 371, pl. 107, figs. 1, 2, (and synonymy).

The specimens examined are not in a good condition, but there are no doubts that they are the present species. The measurements and localities are as follows:

R	r	R:r	Locality	Depth	Collection	Station
55mm	31mm	1.5	Omaesaki	505 fms	Albatross, 1906	5080
80mm	47mm	1.7	Sio-Misaki	600 fms	„	4973
83mm	52mm	1.6	„	587 fms	„	4969

Diagnosis. Disc depressed, rays five; R 1.4 to 1.7r; stellato-pentagonal form; supradorsal membrane tough, with well developed muscular bands, bristling with the prominent central spines of each paxilla; paxilla with a long pedicel surmounted by a prominent central stout spine and 7–8 slender shorter radiating peripheral spines; spiracula around the central spines; ventrolateral membrane rather thick and broad; adambulacral combs of two kinds; prominent combs with 6 or 7 webbed spines; nonprominent with 5 or 6; mouth plates with 5 or 6 spines; two series united by a continuous membrane; a suboral spine.

Description. Disc depressed, stellato-pentagonal form. Supradorsal membrane tough, bristling with stout central spines or protruded through. Pedicels long, measuring about 9 mm in length and each surmounted by a stout central spine, about 7 mm long and

7 or 8 slender, short peripheral radiating spines. These spines are joined together by a muscular band. Spiracula disposed radially around the central spine, though occasionally irregular.

There are two kinds of adambulacral combs; the one projecting further into furrow than the other. In Japanese specimens the adambulacral spines are a little numerous than in Fisher's specimens. Prominent combs each with mostly 6 or 7 spines alternating with nonprominent combs with 5 or 6 spines in each. The innermost spines of prominent combs are generally fewer by one than those of the prominent one, but they are occasionally equal in number in these two combs by the addition of a small spinelet situated deep in the furrow of the former comb. The innermost spines of prominent combs are generally much shorter and slenderer than the others, and also in the nonprominent ones, the one or two inner spines are short and slender. The outer spines of both combs are long, nearly equal in length or slightly decrease in length outwardly.

Mouth plates each with 5 or 6 oral spines; the two series are united by a common membrane. Behind them stands a slender long suboral spine, subequal in length to long oral spines. Ambulacra wide, tube-feet arranged in four rows.

Ventrolateral membrane rather thick and broad. Adamulacral webs not so far prolonged to the area. Aperture papillae very prominent, elongated ovate, free in the aboral edge.

Localities. Omaesaki and Sio-misaki.

Distribution. Circumpolar; known from the north Atlantic; in Pacific from the Bering Sea to California along American side; on Asiatic side southward to Sio-misaki, Japan.

Genus *Hymenaster* W. THOMSON

Hymenaster: W. THOMSON, 1873, p. 120; FISHER, 1911, p. 373.

Hymenaster glaucus SLADEN

(Pl. 12, fig. 3, pl. 13, figs. 2, 3.)

Hymenaster glaucus: SLADEN, 1889, p. 505, pl. 84, figs. 1, 2, pl. 86, figs. 4–6.

Seven specimens were examined, measurements and localities being as follows:

R	r	R:r	Locality	Depth	Collection	Station
46mm	30mm	1.5	Aniwa Bay	507 fms	Albatross, 1906	4980
53mm	37mm	1.4	„	„	„	„
65mm	50mm	1.3	„	„	„	„
70mm	50mm	1.4	„	„	„	„
100mm	70mm	1.4	„	„	„	„
110mm	77mm	1.4	Okhotsk Sea	514 fms	„	5078
105mm	——	—	Sio-Misaki	600 fms	„	4973

Diagnosis. Rays five; R 1.3 to 1.5r; body depressed, general form nearly pentagonal; extensive interradial webs supported by stout ventrolateral spines; marginal paxillae conspicuously larger than the medians; spiracula scattered, not numerous; very numerous crisscrossing muscule fibres radiating from tips of paxillar spines; adambulacral spinelets two or three; oral spines 4 or 5; suboral spines 2; aperture papillae ovate.

Description. The species closely resembles *Hymenaster perissonotus* Fisher. Supradorsal membrane thin, with very numerous crisscrossing muscle fibres radiating from the tips of paxillar spines, spiracula scattered all over the surface, but not numerous. Paxillar areas slightly elevated from a general surface broadly petaloid, but supradorsal membrane resting on the ambulacral ridge at the distal half portion of ray. Paxillae of median radial region small, each with a short pedicel surmounted by three short slender spinelets. They gradually decrease in size toward arm tip, but rapidly increase in size toward lateral sides, the lateralmost being the largest, with four long spines. In a specimen (R 105 mm) radial paxillae located on the middle of ray, with spines, 2–2.5 mm long and pedicels, about 1 mm long and marginal paxillae corresponding to the paxillae, with spines, about 9 mm long, and pedicels, about 5 mm long. Oscular aperture large and conspicuous, the inner valves each with 10 or more spines, while the outer ones each with 4 or 5 shorter spines. Aboral skeleton not so exceedingly weak as stated by Fisher ('11) for *perissonotus*. Plates slender cruciform, forming very regular oblique transverse quadrate net work.

Ventrolateral spines spaced, robust, gradually increasing in length and thickness along the ray toward the tip and become stoutest and longest in three-fourth the length of ray, then become short rather rapidly. Membrane rather thick.

Adambulacral furrow fairly wide, tube-feet in two rows. Adambulacral plates generally each with two short pointed spines and

occasionally three. Mouth plates each with 4 or 5 oral spines, similar to adambulacral spines in size, suboral spines double, thick and robust; the aboral one of the two is generally stouter than the adoral one. Aperture papilla large with an elongated lanceolate overlap.

Localities. Aniwa Bay and Sio-misaki.

Distribution. Only from Japan.

Explanation of Plate VII

Fig. 1. Aboral side of *Henricia pacyderma* n. sp. About natural size.
Fig. 2. Oral side of the same specimen. About natural size.
Fig. 3. Aboral side of *Henricia saghaliensis* n. sp. About natural size.
Fig. 4. Oral side of the same specimen. About natural size.
Fig. 5. Aboral side of *Henricia exigua* n. sp. About natural size.
Fig. 6. Oral side of the same specimen. About natural size.
Fig. 7. Aboral side of *Henricia kinkasana* n. sp. About natural size.
Fig. 8. Oral side of the same specimen. About natural size.
Fig. 9. Aboral side of *Henricia aspera.* About natural size.
Fig. 10. Oral side of the same specimen. About natural size.
Fig. 11. Aboral side of *Henricia reniossa* forma *tohokuensis* n. forma. About 1/3×.
Fig. 12. Oral side of the same specimen. About 1/3×.

Explanation of Plate VIII

Fig. 1. Aboral side of *Henricia nipponica.* About natural size.
Fig. 2. Aboral side of *Henricia nipponica.* About natural size.
Fig. 3. Aboral side of *Henricia nipponica.* About natural size.
Fig. 4. Oral side of *Henricia nipponica.* About natural size.
Fig. 5. Aboral side of *Henricia tumida.* About natural size.
Fig. 6. Oral side of the specimen. About natural size.
Fig. 7. *Henricia tumida,* showing the skeletal structure of brood pouch. About natural size.
Fig. 8. Oral side of *Henricia tumida,* having brood pouch. About natural size.
Fig. 9. Aboral side of the specimen. About natural size.
Fig. 10. Oral side of *Henricia tumida,* female, obtained from Unalaska. About natural size.
Fig. 11. Aboral side of the same specimen. About natural size.
Fig. 12. Aboral side of *Henricia tumida,* male, obtained from Unalaska. About natural size.
Fig. 13. Aboral side of the same specimen. About natural size.
Fig. 14. Aboral side of *Henricia leviuscula.* About 2/3×.
Fig. 15. Oral side of the same specimen. About 2/3×.
Fig. 16. Oral side of *Henricia reniossa* n. sp. About 2/3×.
Fig. 17. Aboral side of the same specimen. About 2/3×.

Explanation of Plate IX

Fig. 1. Aboral side of *Henricia reticulata* n. sp. About natural size.
Fig. 2. Oral side of the same specimen. About natural size.
Fig. 3. Oral side of *Henricia leviuscula spiculifera*. About natural size.
Fig. 4. Aboral side of the same specimen. About natural size.
Fig. 5. Oral side of *Henricia Ohshimai*. About natural size.
Fig. 6. Aboral side of the same specimen. About natural size.
Fig. 7. Aboral side of *Henricia pacifica* n. sp. About natural size.
Fig. 8. Oral side of the same specimen. About natural size.
Fig. 9. Aboral side of *Henricia pacifica* n. sp. About natural size.
Fig. 10. Oral side of the same specimen. About natural size.

Explanation of Plate X

Fig. 1. Aboral side of *Henricia irregularis* n. sp. About natural size.
Fig. 2. Oral side of the same specimen. About natural size.
Fig. 3. Aboral side of *Henricia regularis* n. sp. About natural size.
Fig. 4. Oral side of the same specimen. About natural size.
Fig. 5. Aboral side of *Henricia Ohshimai* forma *acutispina* n, forma. About natural size.
Fig. 6. Oral side of the same specimen. About natural size.
Fig. 7. Oral side of *Henricia densispina*. About natural size.
Fig. 8. Aboral side of the same specimen. About natural size.

Explanation of Plate XI

Fig. 1. Oral side of *Pteraster tesselatus* forma *glomus* n. forma. About 2/3×.
Fig. 2. Aboral side of the same specimen. About 2/3×.
Fig. 3. Oral side of *Pteraster uragaensis* n. sp. About natural size.
Fig. 4. Aboral side of the same specimen. About natural size.
Fig. 5. Aboral side of *Asterina coronata* forma *japonica*. About natural size.
Fig. 6. Aboral side of *Asterina coronata* forma *japonica*. About natural size.
Fig. 7. Aboral side of *Asterina coronata* forma *japonica*. About natural size.
Fig. 8. Aboral side of *Pteraster jordani*. About 2/3×.

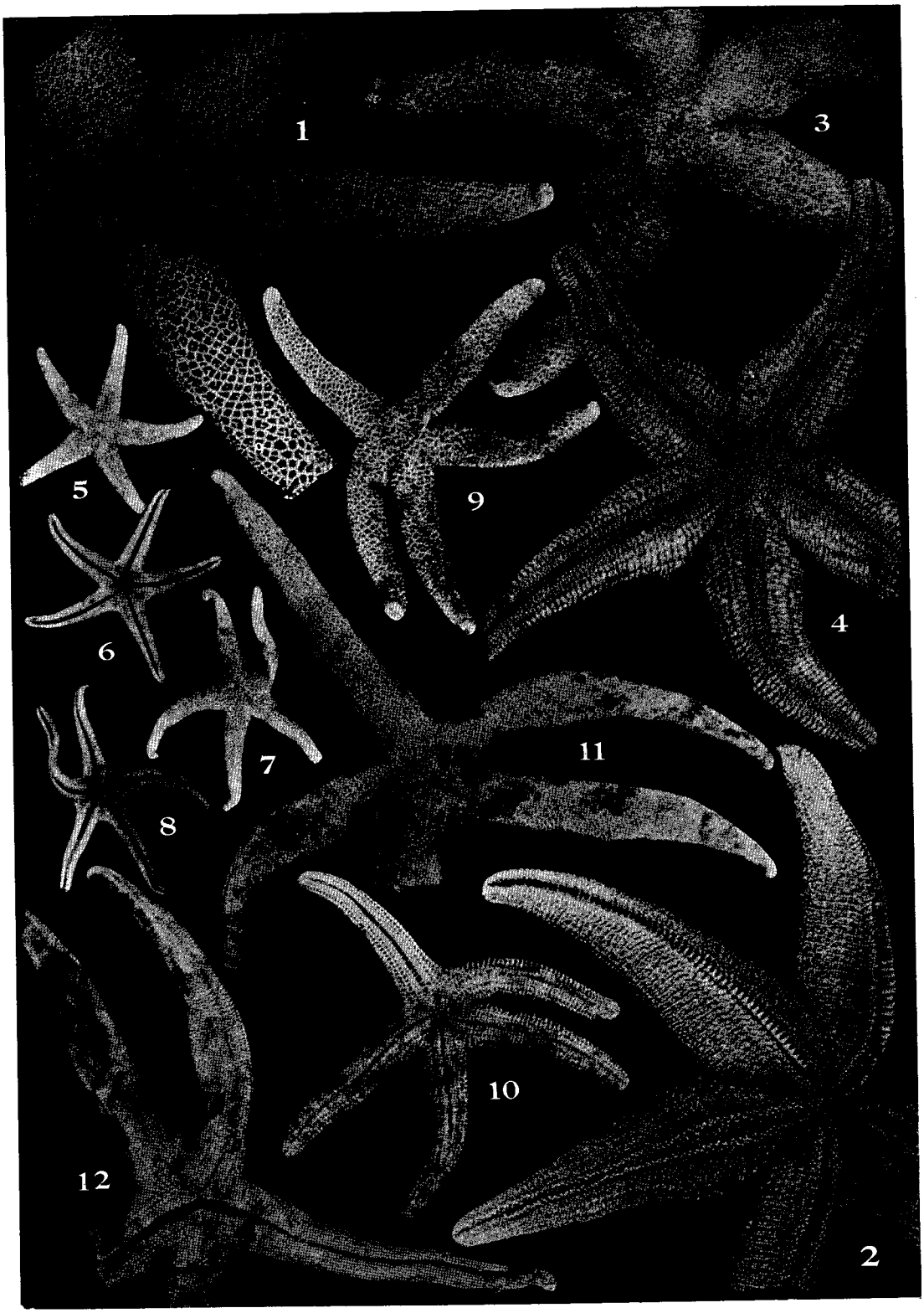
Explanation of Plate XII

Fig. 1. Aboral side of *Diplopteraster multipes*. About 2/3×.
Fig. 2. Oral side of *Pteraster jordani*. About 2/3×.
Fig. 3. A portion of aboral skeleton of ray in *Hymenaster glaucus*. About natural size.

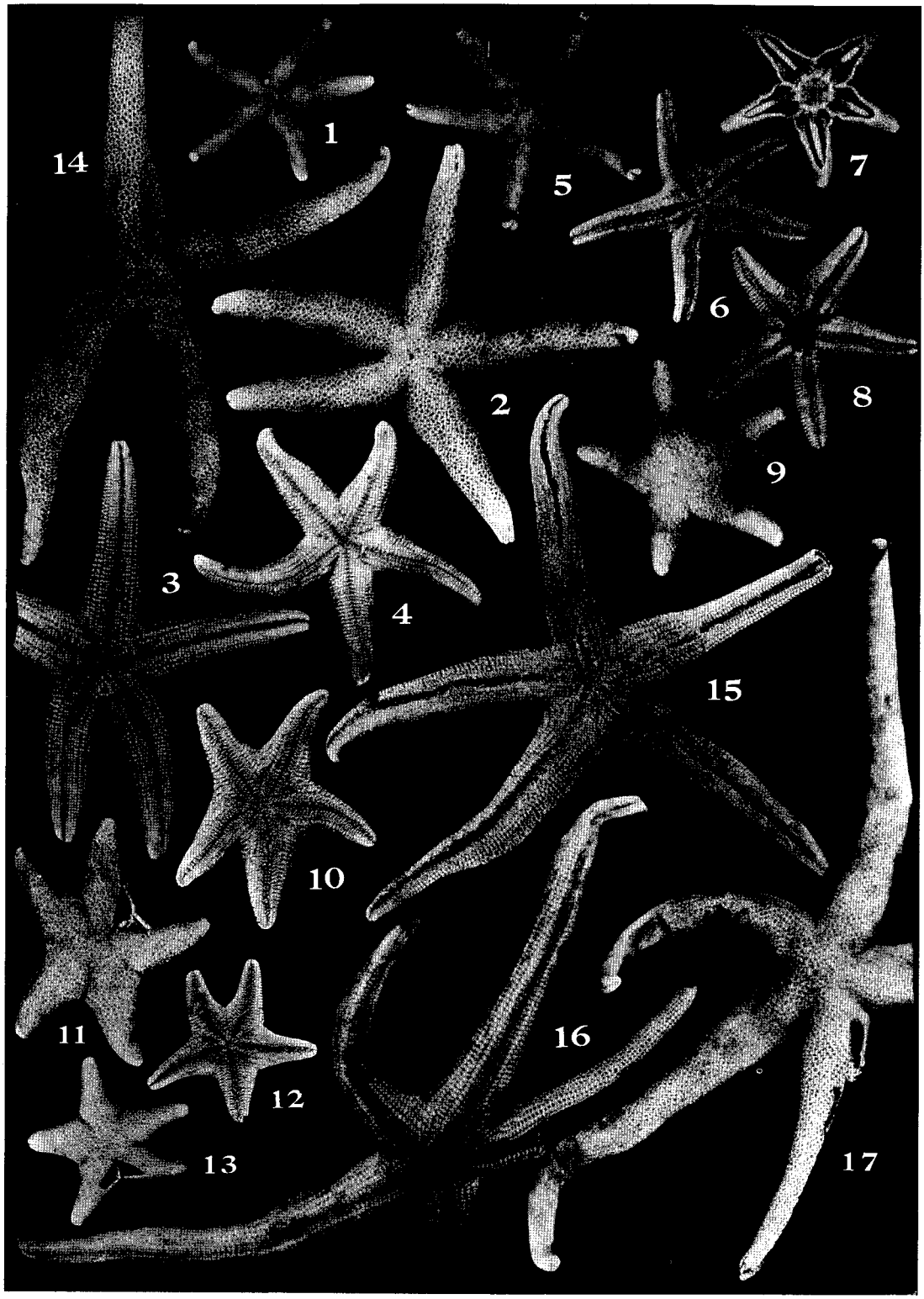
Fig. 4. Aboral side of *Pteraster obscurus* with 6–rays. About natural size.
Fig. 5. Oral side of the same specimen. About natural size.
Fig. 6. Aboral side of *Pteraster obscurus* with 9 rays. About ½×.

Explanation of Plate XIII

Fig. 1. Oral side of *Diplopteraster multipes*. About 2/3×.
Fig. 2. Aboral side of *Hymenaster glaucus*. About 2/3.
Fig. 3. Oral side of the specimen. About 2/3×.
Fig. 4. Oral side of *Pteraster obscurus* with 9 rays. About ½×.
Fig. 5. Aboral side of *Asterina batheri*. About natural size.
Fig. 6. Oral side of the specimen. About natural size.
Fig. 7. Oral side of *Asterina coronata* forma *japonica*. About natural size.

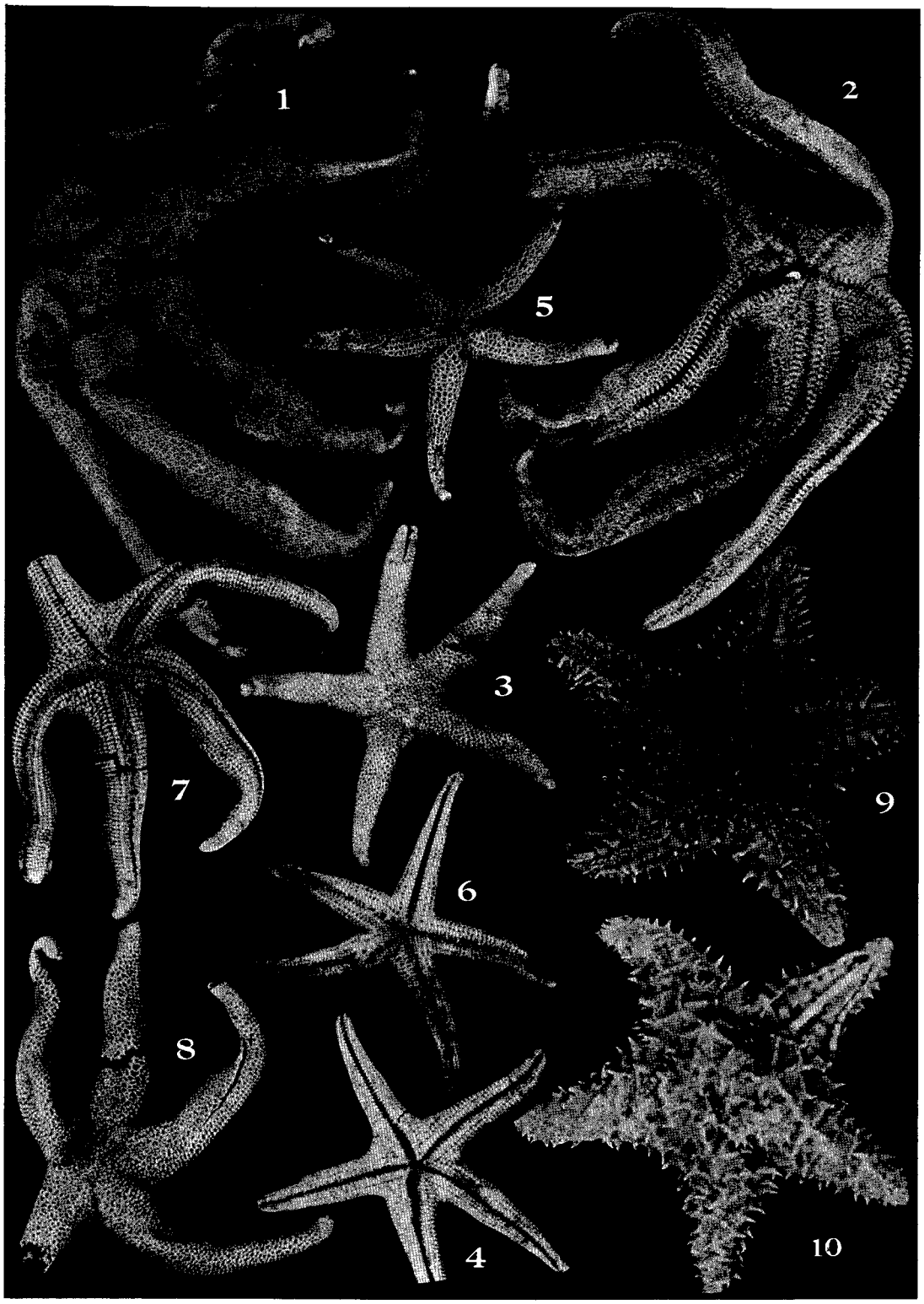


R. Hayashi: Sea-stars of Japan, I. Spinulosa



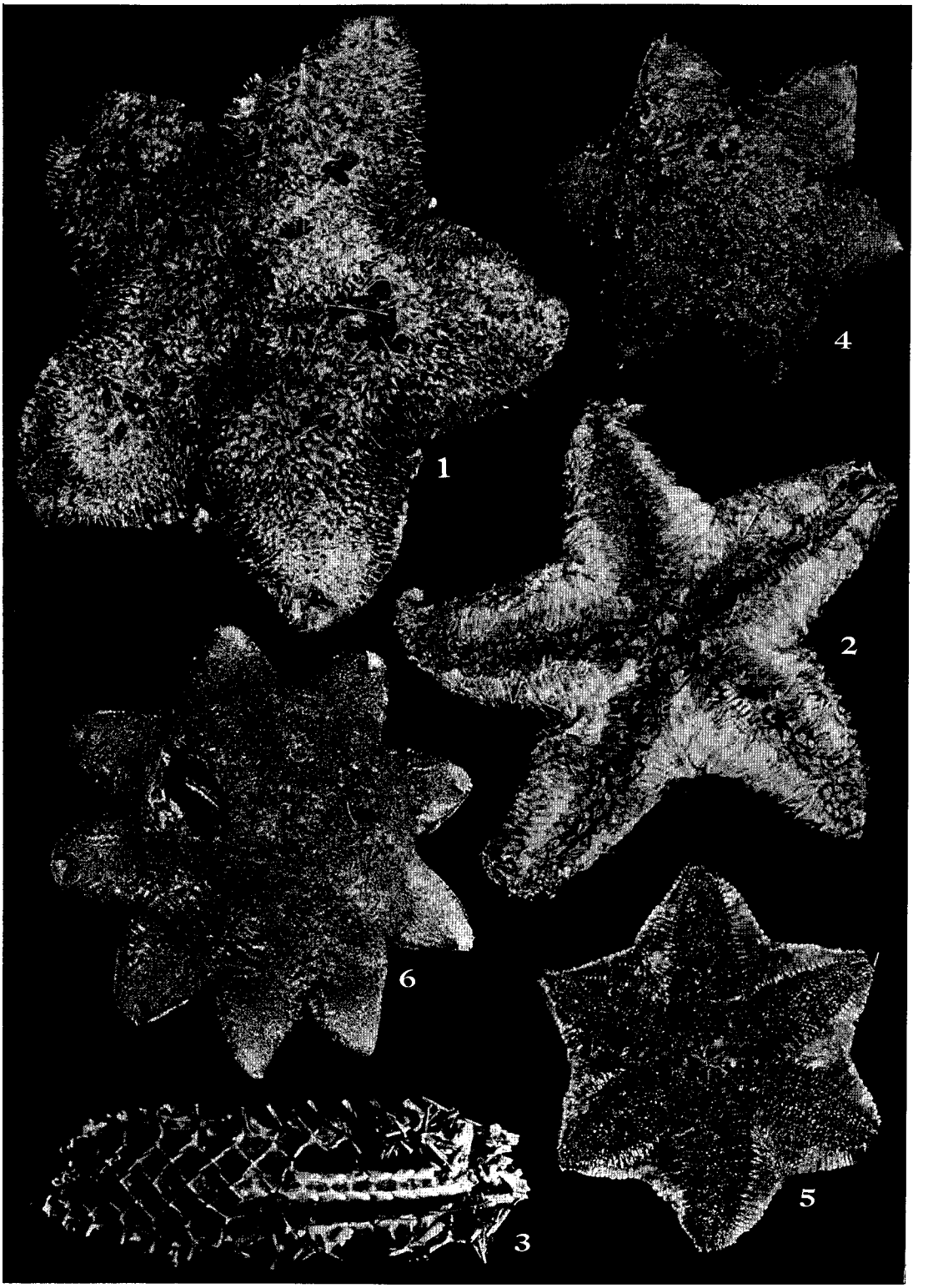
R. Hayashi: Sea-stars of Japan, I. Spinulosa

R. Hayashi: Sea-stars of Japan, I. Spinulosa



R. Hayashi: Sea-stars of Japan, I. Spinulosa

R. Hayashi: Sea-stars of Japan, I. Spinulosa



R. Hayashi: Sea-stars of Japan, I. Spinulosa

R. Hayashi .· Sea-stars of Japan, I. Spinulosa