Notes on the Paludina-Species of Japan.

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With Pl. V.

While engaged in reärranging the shell collection of the Imperial Museum at Uyeno, Tokyo, I have found among it a pretty extensive series of native *Paludina* specimens from localities ranging from Awomori at the north-eastern extremity of Hondō as far south-west as the island of Shikoku. Advantage was taken of this opportunity to make a systematic study of the genus, but as I soon felt the desirability of having more materials in order to arrive at satisfactory results, and especially as the labelling of localities appeared in some cases unreliable, I have given special attention to obtaining fresh paludinas while on a collecting tour in the northern provinces during the summer of 1896. On that occasion, I enjoyed the agreeable company and valuable assistance of Prof. C. ISHIKAWA and also the coöperation of Messrs. K. MATSUURA and I. HORIKAWA, assistants to the Zoological Department of the Imperial Museum. Two hundred and eighteen fresh specimens were brought home from different localities, chiefly in the provinces of Mutsu, Rikuchu, Rikuzen, and Iwashiro. These, added to the old specimens of the Museum, formed a material of over five-hundred, which number further received considerable augmentation through the kind gifts of several friends in different parts of the country. For specimens from middle Japan I am especially indebted to Mr. M. KAWATSURA of Kamisuwa, Prov. Shinano, and to Mr. Y. NAWA of Gifu. Mr. KUROIWA of the Normal School of Naha has kindly sent me specimens from Yayeyama Shima, Loo-choo Islands. To all the gentlemen above named I wish here to tender my thanks.

In Dr. W. KOBELT'S well-known work "Fauna Japonica extramarina" (1879), are given the following eight species:

1. *Paludina japonica*, v. Martens. Hab. Tokyo, Yokohama, Hakone Lake.
2. *Paludina Sclateri* (v. Frauenfeld). Hab. Biwa Lake.
3. *Paludina stelmaphora* (Bourgnignat). Hab. Tokyo, Yokohama, Biwa Lake, Yawatahama.
4. *Paludina oxytropis*, Benson. Locality not specially mentioned.
5. *Paludina ingallsiana*, Reeve. Hab. Biwa Lake.
6. *Paludina nitens*, Reeve. Hab. "Japan."
7. *Paludina abbreviata*, Reeve. Hab. "Japan."
8. *Paludina laeta*, v. Martens. Hab. "Japan."

Of the three last-mentioned species, viz. *nitens*, *abbreviata*, and *laeta*, there exist but very meagre diagnoses and no figures. It seems these species were never found again since they were first described. Indeed, there are not wanting in my collection certain specimens which somewhat approach the diagnosis of one or the other of them, but I found anything like satisfactory identification impossible. More specimens from the south-western provinces, which are still in need of thorough exploration, might possibly throw light on the validity or non-validity of the three species in question; but, considering the great variability of other well-established species, it is exceedingly doubtful if any of them would ever be found tenable as distinct species.

On the other hand, the remaining five species or forms given by KOBELT are represented in my collection, although they can not all be held up as specifically distinct. In fact, I can recognize in my material only three species, viz. *stelmaphora*, *ingallsiana*, and *oxytropis*.

Pal. stelmaphora and *Pal. ingallsiana* present no difficulty in being regarded as good species. Whereas, *Pal. japonica*, *Pal. Sclateri* and *Pal. oxytropis* has seemed to me rather doubtful as to their specific distinctness from the outset, since they were often found mixed together in one and the same locality. A thorough study of my specimens revealed the fact that both *japonica* and *Sclateri* insensibly grade over to *oxytropis*,

and must therefore be looked upon as varieties of the latter.

In identification I have found it of great importance to bring into consideration the form of young shells in different stages of growth, either found free or taken from within the body of mother shells. For, the young have characteristic shape for each species and are very persistent in their characters in comparison with adults.

1. *Paludina stelmaphora* (Bourgnignat).

Pl. V, figs. 1—4.

The specimens which I refer to this species, have characters essentially agreeing with the original diagnosis of BOURGNIGNAT and with the description given by KOBELT (*loc. cit.*, p. 122). The principal characters are as follows:

Shell swollen, egg-shaped, thin, smooth, with a greenish epidermis, umbilicated. Spire low, with an obtuse apex usually worn out in old specimens. Whorls quite rounded, separated by deep sutures; each whorl wound round with three punctured lines, which, though sometimes extremely fine, are always present and easily visible to the naked eye. In young individuals the lines are often beset with fine hairs. These punctured or haired lines seem to be peculiar to this species; they are not found in any other Japanese species of *Paludina*, in which we find raised lines instead. They were described by KOBELT but were omitted in his figures. Aperture nearly round, obtusely angled at the upper end. Edge of outer lip turned out, consisting of a thin epidermis which is connected with the inner lip by a thin callosity, margined with a black band. In fully grown specimens, the surface of the body-whorl is provided, especially close to the outer lip, with some elevated ribs besides the several lines of growth. Interior of the aperture bluish-colored. Height 43—58 mm. Diameter 26—36 mm. Aperture 22—30 mm. long, 19—23 mm. wide.

Specimens of this species very often present hammered-like sculpture on the surface (*P. malliata*, Reeve). As was correctly recognized by KOBELT, these should not however be made into a distinct

species, since they are connected by intermediate forms with those that are devoid of the sculpture. A collection of *stelmaphora* from one and the same locality may show an abundance of transitional forms from smooth-surfaced individuals to others that have a distinct hammered-like surface. Moreover this character of the shell is not peculiar to *stelmaphora*, being also met with in some individuals of *oxytropis*.

The embryo-shell (fig. 1) of this species is amber-colored and extremely delicate, consisting of only three or four whorls with a very low spire. Each whorl is perfectly rounded at the shoulder except on the body-whorl which is somewhat angular along the middle and is besides provided with exceedingly fine spiral lines. The aperture is generally rounded above, while its basal portion at the lower end of the columella is stretched out so as to form a short canal. As the shell grows, the angle on the body-whorl generally disappears and the three punctured lines characteristic of this species are developed (fig. 2—4).

I have specimens of *P. stelmaphora* from Awomori in Prov. Mutsu, Kogawara Swamp in Prov. Rikuchu, Miyagi in Prov. Rikuzen, Fukushima in Prov. Iwashiro, Kasumigaura in Prov. Hitachi, Tokyo, Aichi in Prov. Owari, Tokushima in Prov. Awa, and Yayeyama Shima. Thus it will be seen that the present species has a very wide distribution in Japan, from Tsugaru Strait as far south as the Loo-choo Islands. At the latter locality, this seems to be the only species of *Paludina* present, according to a private communication of Mr. KUROIWA.

Further it may be noted that this species is confined to shallow water broadly exposed to light, such as rice-fields. So far as my observation goes, it never occurs in such places as lakes or rivers where water is deep and cold.

2. *Paludina ingallsiana*, Reeve.

Pl. V, figs. 5—7.

This is an exceedingly variable species, the several forms of which are well represented and described in KOBELT'S monograph. Notwith-

standing its variability, the species is easily distinguishable by the following characters:

Shell pyramidal or turret-shaped, with apex sometimes extensively worn out in mature specimens. Sutures deeply canal-like, owing to the abruptly outstanding edges of whorls, between which edges the whorl-surface is flat or even slightly concave. In some specimens, each whorl is provided with two or three distinct, spiral raised lines; in others there is only one such line on the body-whorl, bringing about an angle at the outer lip. The surface is either rough and incrusted with a reddish substance or perfectly smooth and vividly green. Height 43—51 mm. Diameter 23—30 mm. Aperture 18—25 mm. long, 14—19 mm. wide.

Fig. 5 represents one of the youngest specimens of *ingallsiana* from Lake Suwa. It will be seen that its shape is quite different from that of the corresponding stage of either *stelmaphora* (fig. 3) or *oxytropis* (fig. 9).

This excellent species has hitherto been known only from Lake Biwa, to which I will now add two more localities, Lake Suwa in Prov. Shinano, and Nagoya in Prov. Owari, on the strength of the specimens contained in the Imperial Museum.

In Lake Biwa, it seems to be very common. Mr. K. MATSUURA incidentally obtained there several specimens, while collecting fresh-water fishes together with Prof. C. ISHIKAWA during the summer of 1895.

From Lake Suwa there was originally only one specimen of this species in the Museum. Recently Mr. M. KAWATSURA of that locality has made a collection at my request and kindly sent me a number of fresh specimens.

With respect to specimens from the Province of Owari, of which there are three in the Museum, the exact locality is unknown.

In the north-eastern provinces of Hondō, I could not obtain a single specimen of this species, in spite of my efforts to collect during the excursion of last summer. It is very desirable to ascertain its range

of distribution in Middle Japan and also in the south-western provinces, where it probably also occurs.

3. *Paludina oxytropis*, Benson.

After disposing of the two species above noticed, the rest of my specimens offered some difficulties in being identified. While some of these were referable to *oxytropis* (after KOBELT), others to FRAUENFELD'S species *Sclateri* and still others to v. MARTENS' *japonica*, there were many with intermediate characters. After all I have come to the conclusion that *japonica* and *Sclateri* must be regarded merely as varieties of *oxytropis*.

Typical *Pal. oxytropis* (fig. 12) has the shape of a double cone. Spire usually acutely pointed, consisting of 6 or 7 whorls; shell thin and translucent, upper whorls only slightly swollen or nearly flat, separated by narrow and shallow sutures; each whorl provided with three or four distinct raised lines, of which the lowest runs at the sutural line, while the remaining lines run so as to divide the whorl-surface into a corresponding number of zones, usually nearly equal, but sometimes unequal in width. The middle portion of the body-whorl forms a distinct angular ridge, below which there are numerous spiral lines converging towards the umbilicus. Aperture oval but more or less acutely angular above and below; peristome thin and sharp, its portion at the lower end of columella alone being a little turned out; all the extremities of raised lines form more or less acute angles at the margin of outer lip.

Pal. oxytropis var. *japonica* (fig. 17) (=*Pal. japonica*, v. Mart.) differs from typical *oxytropis* in the following characters: shell ovoid-conical, moderately thick and opaque, usually with somewhat obtusely pointed spire; whorls swollen, separated by wide and deep sutures; raised lines indistinct or absent except one on the body-whorl, where it makes a very slight angular ridge. Aperture nearly round, with an obtuse angle only at the upper end, and with thick peristome, which is considerably expanded outwards and downwards.

Pal. oxytropis var. *Sclateri* (fig. 14) (=*Pal. Sclateri* v. Fr.) is distinguished from the typical form by having oval, thicker and heavier shell, with an obtuse apex; whorls swollen, but not so much as in the above variety, and separated by very shallow sutures. Raised lines persist in each whorl, though not so prominent as to give rise to angles at the peristomal margin. Aperture oval, with obtuse angles above and below; edge of peristome very thick, and the outer lip slightly expanded outwards.

Notwithstanding the differences of adults, the young of the typical form and of its varieties all agree in characters. The embryo-shell (fig. 8) is light green and consists of five whorls, with a conical pointed spire. Three raised lines are distinctly to be seen. The last of these lines brings about a conspicuous angle at the margin of the outer lip, the aperture showing four angles in all. The general shape of the shell is that of a double cone.

The main features of embryonal characters above referred to are retained during the growth of the shell (figs. 8—11), to be directly continued further on into the adult stage in the case of typical *oxytropis*, but to deviate at a certain period of growth into the respective definitive characters of *japonica* and *Sclateri*, where these are concerned. This is the ground on which I base my conclusion that *oxytropis* represents the primitive stock, whence *japonica* and *Sclateri* have differentiated.

I will here let follow an account of the specimens collected by myself at different localities in the north-eastern provinces to illustrate how this species varies.

1) Most of the specimens from a muddy stream in Yamagata village near Lake Inawashiro, Prov. Iwashiro, distinctly show the characters of typical *oxytropis*. Fig. 12 was drawn from one of the specimens collected at that place. In four out of fourteen specimens obtained, the spiral raised lines were either indistinct or nearly absent while the whorls were more or less swollen, which characters made them approach either *japonica* or *Sclateri*. In the majority of specimens the three

raised lines were prominent; in some there were one or sometimes two more lines interposed between the first and the second, and in still others another raised line was added above the first. The angular edge of the body-whorl was very prominent in all Yamagata specimens.

The largest individual of the lot measured 70 mm. in height and 55 mm. in diameter, with an aperture 39 mm. long and 29 mm. broad.

2) In the specimens from Shinai Swamp in Prov. Rikuzen, eighteen in all, both typical *oxytropis* and var. *japonica* are represented. Eight are referable to the former and the rest to the latter. In all and even in old specimens the apex is uninjured and the shell perfectly smooth, and vividly green in color. The typical *oxytropis* specimens, although of normal configuration in young stages, have somewhat lower raised lines than those of Yamagata. This seems to indicate that Shinai specimens have a greater tendency to change into *japonica* form.

3) The specimens from a small swamp near the village of Nagahama on the northern shore of Lake Inawashiro are all var. *Sclateri* in both the shape and thickness of the shell, but they still retain the character of typical *oxytropis* in so far as the prominent raised lines are present. The embryo-shells have typical *oxytropis* shape.

4) In specimens from a canal near the village Shariki, Prov. Mutsu, the definitive characters of var. *Sclateri* are settled, although the embryo-shells are typical *oxytropis* as ever.

5) The specimens from Hirobuchi Swamp, Prov. Rikuzen, show abundance of transitional forms, typical *oxytropis* into var. *Sclateri*, while the tendency to change into var. *japonica* is indicated only in a slight degree. In all cases, embryo-shells have the shape of the typical species.

6) Finally, the specimens collected at Kogawara Swamp, Prov. Rikuchu, are of great interest in that they serve for definitely settling the question as to the mutual relationship of the three forms. The young have invariably the shape and characters of typical *oxytropis* (figs. 8—11). Among the adults the *Sclateri* form prevails. There are besides unmistakable *japonica* form and others that combine the charac-

ters of the typical *oxytropis* with those of either *Sclateri* or *japonica*. Adults with the characters of typical *oxytropis* are not found in this lot.

In fig. 14 I have represented a specimen from this locality, which must certainly be considered as *Sclateri*. In its general shape, the form of the aperture and the nature of raised lines, it tallies well with the description and figures given by KOBELT of that form.

Fig. 17 represents a specimen from the same locality, which is a true *japonica* characterized by outbulged whorls, by the expanded outer lip of the aperture and by the partial absence of raised lines. The young specimen drawn in fig. 9 was taken from this individual.

As examples of varieties with combined characters, I have given figures of three specimens in figs. 13, 15, and 16. Both the specimens of figs. 13 and 16 have almost the shape of *Sclateri*, but at the same time approach *oxytropis* in the character of raised lines, which is especially the case with the specimen of fig. 13.

The individual of fig. 15 is nearly *oxytropis* in its general shape, but the raised lines have all disappeared except one on the body-whorl, in which respect it is like *japonica*.

I wish to emphasize once more that the young of all the varieties above mentioned are essentially *oxytropis* in character, so that figs. 8—11 might pass as young stages of any one of them. Here is, I think, a sufficient ground to conclude that *Pal. oxytropis* represents the ancestral species whence the several varieties have arisen.

EXPLANATION OF FIGURES.

Fig. 1—3. Three young stages of *Pal. stelmaphora* from Shariki, Prov. Mutsu.
4. An adult form of ditto.
5—6. Two young stages of *Pal. ingallsiana* from Suwa Lake, Prov. Shinano.
7. An adult form of ditto.
8—11. Four young stages of *Pal. oxytropis* from Kogawara Swamp, Prov. Rikuchu.
12. *Pal. oxytropis*, a typical form from Yamagata, Prov. Iwashiro.
13—16. Two intermediate forms between *oxytropis* and *Sclateri* from Kogawara.
14. *Pal oxytropis* var. *Sclateri* from ditto.
15. An intermediate form between *oxytropis* and *japonica* from ditto.
17. *Pal. oxytropis* var. *japonica* from ditto.

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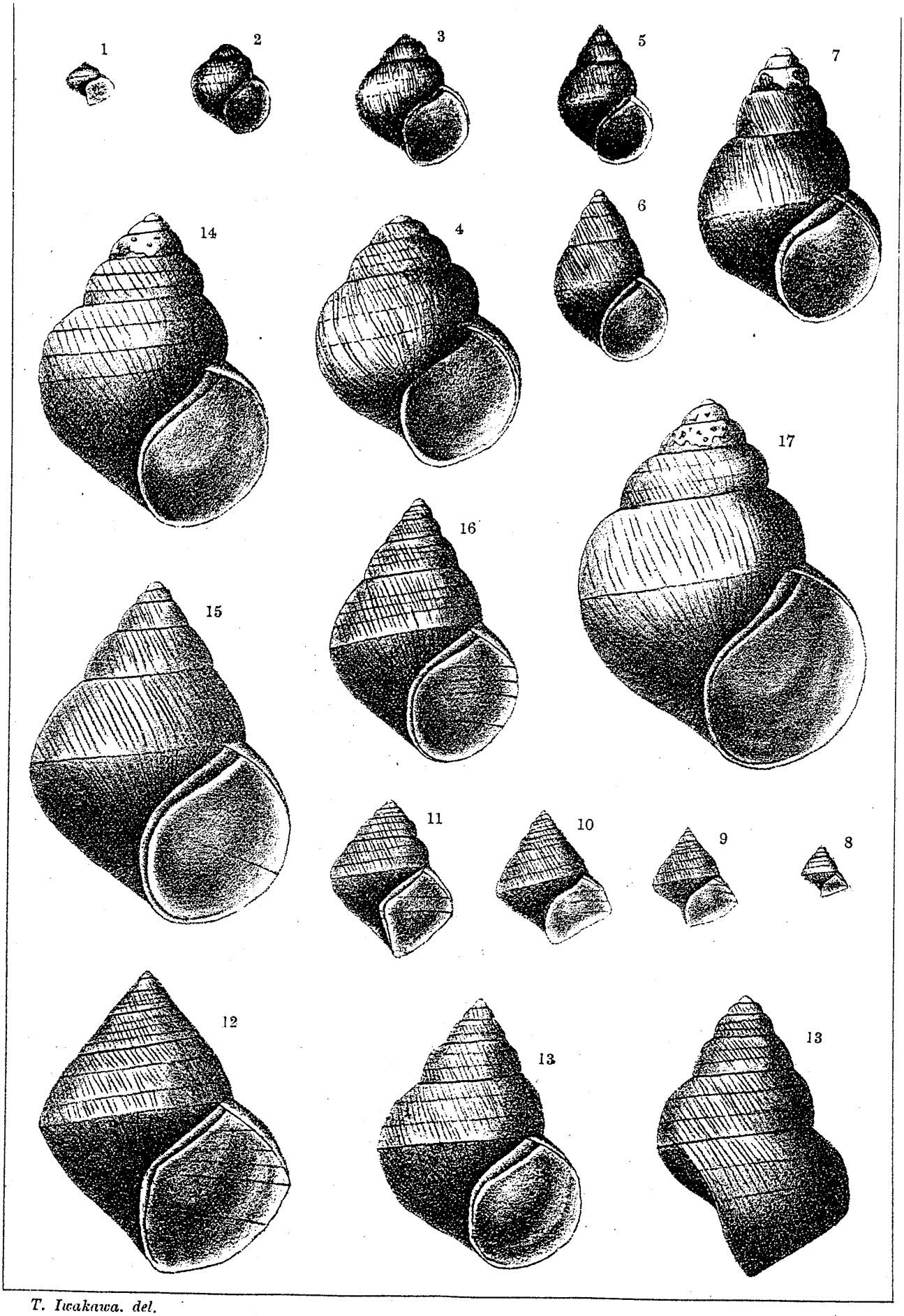

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