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[JULY, 1891.]

THE
SCIENTIFIC TRANSACTIONS
OF THE
ROYAL DUBLIN SOCIETY.

VOLUME IV. (SERIES II.)

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THE SLUGS OF IRELAND. BY R. F. SCHARFF, PH.D., B.Sc., Keeper of the Natural
History Museum, Dublin. Plates LVI., LVII.

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X.

THE SLUGS OF IRELAND. BY R. F. SCHARFF, PH.D., B.Sc., Keeper of the
Natural History Museum, Dublin. PLATES LVI. & LVII.

[Read MARCH 9, 1891.]

THE term "Slug," used in the ordinary sense, is applied to snails without an external shell. Anatomically, the slugs cannot be grouped into one distinct family apart from the snails. Even of the few genera inhabiting Ireland, *Limax*, *Agriolimax*, and *Amalia* must be placed in one family with the Helices, to which they are much more closely related than they are to *Arion* and *Geomalacus*, the two other Irish genera of slugs.

From a systematic point of view a description of these animals, leaving unmentioned the closely-related snails, may seem rather unscientific, but this work has been undertaken chiefly with a view of solving some of the difficulties regarding the distribution of terrestrial animals; and land snails having been known to be transported by sea, as has been shown by Darwin (*Origin of Species*, 6th ed., p. 353), are of less importance in this respect than slugs. The sea, which is the principal means of communication for other animals and plants between mainland and island, forms an almost impassable barrier for slugs, sea-water being deadly both to their eggs and themselves; therefore, if we find the slugs of mainland and island agreeing in anatomical characters, we may generally conclude that the island must have had a land connexion with the mainland at some time or other, and the more closely related the forms are, the more recent must have been this connexion.

The slugs of Ireland are very closely related, and in most cases are identical with those on the Continent of Europe. It is not my intention, however, to enter in this Paper more fully into the cause of the geographical distribution of slugs, as I propose to deal with the question in a subsequent communication.

Until quite recently, the tongue, or radula, of Mollusca has formed one of the chief characters in the classification, and the separation of one species from another. Specific distinction was based almost entirely on external characters and on

the structure of the radula; and new species have, in consequence, made their appearance in overwhelming numbers. Simroth (38) changed this unfortunate state of things by the production of an elaborate treatise on the German slugs, in which he bases his classification chiefly on the form of the reproductive organs and the intestine. He showed that the radula is subject to much individual variation, and that it is, perhaps, the most unsuitable portion of the slug's body for the purpose of classification. By his anatomical investigations he was enabled to reduce considerably the number of European species, as given in such a recent work as that of Westerlund (44). Among a number of species of *Limax* mentioned in the latter work, fifteen supposed genuine species proved, on examination of the internal organs, to be mere varieties of *Limax maximus*.

Slugs are not alone of importance as regards the geographical distribution of animals. I hope to be able to show in a separate chapter that their colour has an important bearing on the subject of colouring in animals generally.

Thompson, in his *Natural History of Ireland* (43), mentions nine species of slugs as occurring in this country. In the most recent list of Irish Mollusca published in 1888, by Taylor and Roebuck (42), this number has been increased to ten, but one of these, as I shall endeavour to show later on, is only a variety. I shall now add four species to the list of Irish slugs, one of which, however, has already been recorded by Roebuck (35), in the *Journal of Conchology*. All these thirteen species, with the exception of one, are also found in Great Britain. This one species, viz. *Geomalacus maculosus*, is not only absent from Great Britain, but also from France and Germany. It appears again in Northern Spain, in the province of Asturias. In Ireland it has hitherto only been found in the County Kerry. This part of Ireland has yielded so many peculiar animals and plants that it deserves very much more attention than it has hitherto received. A thorough scientific investigation of that interesting county would, no doubt, reveal a number of forms new to the British fauna and flora.

The thirteen species of Irish slugs belong to five genera, viz. *Limax*, *Agriolimax*, *Amalia*, *Arion*, and *Geomalacus*. In most of the British text-books, the three first are united under the genus *Limax*, but the reasons for separating them will be found under the headings of the respective genera. Lessona and Pollonera (21), and others, have placed the very common Irish slug *Limax marginatus* (= *arborum*) in a separate genus, *Lehnannia*, but I have not thought it advisable to adopt this subdivision of the remaining species of *Limax*.

The species of the three first genera can be very readily distinguished from those of the genus *Arion*, by the absence of the caudal gland. This gland is present in *Geomalacus*, but it is not nearly so conspicuous as in *Arion*, in which its triangular opening at the end of the body is well seen.

The colour of the mucus is not of very great importance, but it is rather

characteristic in *Amalia carinata* and *Agriolimax agrestis*, being always tough and sticky in the former, and milky in the latter.

The presence of dark lateral bands in most slugs from the very day of their birth, has induced Simroth (38) to regard them as an ancestral character; and, in referring to them, he speaks of the ancestral bands ("Stammbinde"). I merely use the term "lateral bands," although in many cases there appear, besides the original ones, two inner bands, one on each side of the median lighter stripe. These inner bands are separated from the lateral bands by a light stripe, and another similar stripe is on the outer side of the lateral bands. Thus, we distinguish band and stripes—the former dark, the other light in colour.

Simroth, in his monograph (38), has placed much weight in the classification of slugs on the nature of their food. However, my own investigations tend to show that there are fungus-eating species among the Limaces as well as the Arions, whilst most species are not particular as to what sort of food they get. Occasionally they all turn carnivorous, and cannibalism is of frequent occurrence.

The plan adopted in this Paper is to give a general concise synopsis of the various genera and species. Under the heading of each species are paragraphs dealing with: 1, External characters; 2, Anatomy; 3, Reproduction; 4, Habitat; 5, Food; 6, General Distribution. The anatomical part has been curtailed to a considerable extent, and only the general outlines of the reproductive organs have been mentioned, which are sufficient in all cases to distinguish one species from another. More elaborate accounts on the general anatomy will be found in Nunneley's (31) and Simroth's (38) works. Neither the shell nor the radula are mentioned, as they do not afford such easy and reliable evidence in the identification of the species as the reproductive organs.

The only papers ever published on Irish slugs are those of the Rev. B. J. Clarke (3), and Professor Allman (1). Although the former is exhaustive as far as it goes, it deals only with what was then believed to come under the head of the genus *Limax*. Professor Allman was the first to describe *Geomulucus maculosus*. The subsequent publications containing reference to Irish slugs are more of the nature of lists.

In Forbes and Hanley's *History of British Mollusca* (9), a few references are made to Irish slugs; and Thompson, in his *Natural History of Ireland* (43), gives a complete list of the species with which he was acquainted. A Paper by Taylor and Roebuck, entitled "Authenticated materials towards a Land and Freshwater Molluscan Fauna of Ireland" (42), contains the most recent list of slugs, with a good many records of localities from all parts of the country. For the past few years Messrs. Taylor and Roebuck have had in preparation a *Monograph of the Land and Freshwater Mollusca of the British Fauna*, which no doubt, will contain a good deal of useful information on the distribution and

variation of slugs. Mr. Roebuck, especially, has for several years made slugs his principal study, and has worked with great energy in extending our information as regards their distribution in all parts of Great Britain and Ireland. Before writing this Paper I consulted Messrs. Taylor and Roebuck, who in consideration of my only dealing with the most neglected portion of the British Islands, kindly promised their support and assistance in my work. The six volumes of the *Journal of Conchology* originated by J. W. Taylor contain a large number of references and records of Irish slugs.

The most important Memoirs on European continental slugs are those of Simroth (38) and Lessona and Pollonera (21). The former chiefly deals with the German forms, and the latter with the Italian. As regards the French slugs, Moquin-Tandon's (26) work is still the most reliable. Although more recent observers have added a good many new species, and even genera to the French Fauna, most of them have to be accepted with great caution.

In concluding these preliminary remarks, I must express my sincerest thanks to Messrs. A. G. More, F. W. Moore, J. R. Redding, G. Barrett-Hamilton, H. B. Rathborne, G. H. Carpenter, Rev. A. H. Delap, and Miss Warren, for specimens, and Messrs. Taylor, Hanitsch, Pollonera, and Simroth, for kind advice, or literary help. The latter was good enough to submit to me part of the proof of his forthcoming memoir on the slugs of Portugal and the Azores, which will appear during the course of the present year.

SYNOPSIS OF THE IRISH GENERA.

A.—Slugs without caudal gland. Pulmonary opening behind the middle of the mantle = *Limax*, *Agriolimax*, *Amalia*.

I.—Mantle with concentric wrinkles = *Limax*, *Agriolimax*.

a. Lateral bands, or a band of spots present, = *Limax*.

b. Lateral bands absent = *Agriolimax*.

II.—Mantle granulated, and with deep horse-shoe shaped groove, = *Amalia*.

B.—Slugs with caudal gland. Pulmonary opening in front of the middle of the mantle = *Arion*, *Geomalacus*.

I.—Caudal gland placed longitudinally = *Arion*.

II.—Caudal gland placed transversely = *Geomalacus*.

GENUS I.—*Limax*. (Linné, 1758).

Body elongated, keeled towards the tail; wrinkles longitudinal on body, concentric on mantle. Longitudinal bands or bands of spots on body and mantle always present in adult; no caudal gland. Pulmonary opening behind middle

of mantle. Reproductive pore near base of upper tentacles. There is a solid internal shell, and the intestine has six convolutions.

In this genus the body is elongated and often strongly keeled posteriorly. The lateral bands are always present in the Irish species, both on the mantle and body; but they may become obscured by being broken up into spots (*L. flavus*), or by the general body colour in the adult becoming black throughout. There is no caudal gland. The pulmonary opening is always situated behind a line drawn across the middle of the mantle. The skin externally is wrinkled, but the wrinkles never are so prominent as they are in the genus *Arion*; they are more pronounced, however, than in *Agriolimax* and *Amalia*, where the skin is almost smooth, especially in the latter.

There are invariably six convolutions of the intestine, sometimes with an additional cœcum. The genital opening is just behind the tentacles, and there is a solid internal shell.

There are three anatomically well-defined species of *Limax* in Ireland: one of them, viz. *Limax marginatus* (= *arborum*, Bouch), differs so much in the structure, of the reproductive organs, as well as in that of the radula, that a separate genus was proposed for it by Heynemann. Simroth (38) was the first to suggest that *Limax variegatus* (= *flavus*) should be united to this new genus *Lehmannia*, as both possess a cœcum to the intestine. But although they have this much in common, the reproductive organs in the two species are not so very similar as to make it desirable to unite them. I think that if any division of the genus *Limax* is made, *Limax marginatus* (= *arborum*) and *L. variegatus* (= *flavus*) should be placed in separate genera. The presence of a flagellum in the reproductive organs of *Limax marginatus* (= *arborum*) also shows some affinity to the genus *Agriolimax*.

SYNOPSIS OF THE IRISH SPECIES OF LIMAX.

- I.—Mantle with dark spots on light ground, or uniformly dark = *L. maximus*.
- II.—Mantle with light spots on darker ground = *L. flavus*.
- III.—Mantle with two lateral dark bands = *L. marginatus*.

Limax maximus, L.

Limax maximus. Linné, *Syst. Nat.* 1758. *Limax antiquorum*, Férussac, *Hist. Moll.* 1819. *Limax maximus*. Jeffreys, *British Conch.* 1862.

(Plate LVI., figs. 1 and 2.)

Colour of body generally a reddish-gray, with dark lateral bands on body, continued to the posterior third of mantle, the remainder of which is spotted. Tentacles long; a faint black line runs along outer margin of foot. Intestine without a cœcum.

External characters.—I have attempted to use the markings of the mantle as a method of readily distinguishing the species of *Limax*, but there is another way, though perhaps not altogether scientific, by which *L. maximus* can easily be identified. If the mantle be touched with a pencil or other sharp instrument, the front portion curls round completely towards the source of irritation, whilst in the two other species the same portion of the mantle will be only slightly lifted. Another character by which *L. maximus* (except in very dark specimens) can be distinguished, is a faint black line, running along the external margin of the foot, which is quite absent in *L. flavus* and *L. marginatus*. Moreover, *L. maximus* is always more slender, and its tentacles are almost double the length of those of *L. marginatus*, in specimens of the same size. The largest specimen I have met with about Dublin, measured 110 mm. long, and 9 mm. broad; but I took one in May, near Lough Caragh, Co. Kerry, which in spirit still measures 85 mm. by 14 mm. As a rule, slugs shrink in alcohol to about one-half their length when alive and fully stretched out; but in this case I think the specimen can hardly have been more than 150 mm. long, which is exactly 6 inches. According to Moquin-Tandon (26), they sometimes grow to the length of 170 mm. in France.

We must not draw too rigid rules as to the limits of the specific characters of this species, for it is subject to much variation in colour, though in Ireland it is by no means the most variable of slugs, as it seems to be in Germany, according to Simroth (38).

All the specimens I have examined, whether they were of various shades of gray, or of a dark brownish colour, were anatomically identical. Roebuck, in his British Slug List (35), refers to *Limax cinereo-niger* (Wolff) as a form which is found in Ireland, and which is now separated by the best Continental authorities from *L. maximus*. He does not mention them, but Simroth (38), one of the best authorities, certainly examined the form, and found it to agree with *L. maximus*. Roebuck states, in the same Paper, that there are important differences between the species in the genital apparatus, but he does not say what they consist in. I, myself, have not had an opportunity of examining a specimen which could be referred to this species, although I have had one or two, which were quite dark above, but leaving the foot white.*

The original lateral bands are always present in quite young specimens. On the posterior third of the mantle they assume a horse-shoe shape without being continued anteriorly. Curiously enough, in the adult, the left part of this horse-shoe becomes almost always broken up into spots, whilst at the right side it generally

* I have quite recently obtained a specimen at Glengariff agreeing in every respect with the description given of *cinereo-niger*. On examination I found no difference anatomically between it and a typical *L. maximus*, except in the origin of the retractor muscle of the penis. This confirms the opinion held above that *cinereo-niger* can only be regarded as a variety of *maximus*.

persists. Thus we usually find that the mantle is uniformly spotted in the adult, except the part between the respiratory orifice and the posterior margin, where we meet with an elongated black mark, the remnant of the lateral band of the mantle. (This is well shown in Reeves' (34) figure of *L. maximus*.) The general body-colour is usually of a faint reddish-gray, turning into pure gray in spirit, whilst the dark spots and bands often become blue. The tentacles are of a light reddish-violet tint. The mucus, on the nature and colour of which rather too much importance has been placed by previous observers, is whitish, and not nearly so abundant as in *L. flavus*, and *L. marginatus*.

Anatomy (Plate LVII., fig. 25).—Both Nunneley (31) and Simroth (38) have given such detailed descriptions of the anatomy, that I need only refer again to the most salient features.

Of the six convolutions of the intestine, four are imbedded in the liver, and two hang freely in the body cavity. The hermaphrodite gland (*hg.*) is elongated and large, and is connected with the ovisperm-duct (*os.*) by means of the hermaphrodite duct (*hd.*) which takes its course through a portion of the albuminiparous gland (*ag.*). The ovisperm-duct is thick and well convoluted, and separates further down into a vas-deferens or sperm-duct (*sp.*) and an oviduct (*ov.*). The former opens into the upper end of a very long penis (*p.*), to which a strong retractor muscle (*rm.*) is attached. The lower portion of the penis unites with that of the oviduct at the genital orifice, so that there is no vestibule. The receptaculum seminis (*rec.*) opens into the lower end of the penis near the junction of the two ducts. Nunneley (31) gives a good figure and description of the reproductive organs, and although he mistook the albuminiparous gland for the testis, this is a comparatively unimportant matter.

Of course, as in all parts of the body, there are variations in the reproductive organs, and it is a matter of opinion whether, in conjunction with external differences in colour, these should be regarded as sufficient to sub-divide the species. Lessona and Pollonera (28), who have published an elaborate monograph on the Italian slugs, are evidently of that opinion, and a good deal may be said in favour of it.

I consider the shell of so little importance as a distinguishing feature that it will be enough to say that it is much larger than in any of the other species.

Reproduction.—The eggs, as far as my observation goes, are deposited in August and September, but I think another deposition takes place earlier in the year. They are very transparent, elastic and slightly yellowish in colour. Their length is 6 mm., and width 4 mm. About a month after their deposition the young appear, and from the first show two distinct lateral bands on the body, reaching to the posterior third of the mantle. The body-colour at this stage is of

a delicate reddish-yellow, the portion of the mantle above the shell being paler, owing to the transparency of the skin.

Its duration of life has generally been fixed at one year. [See Moquin-Tandon (26) and Simroth (38).] I took large specimens on the west coast in May, with reproductive organs almost fully developed, and have everywhere taken numerous half-grown ones in September; therefore I conclude that eggs are laid twice in the year. Lehmann (20) seems to be of the same opinion. It is probable that large specimens owing to the scarcity of food have less chance of surviving winter than small ones, so that comparatively few will be fully developed in the following June. In the West, where the climate is milder, large ones find food more plentifully throughout the winter, and we thus meet with many full-grown specimens by May.

Habitat.—" *L. maximus*," Miss Warren wrote to me some time ago from Co. Mayo, "is a solitary species, which may be explained by the fact that it is a great traveller." This agrees exactly with my own observation. One finds either a solitary specimen or two not far from one another, but rarely more.

There are frequent references [see Leach (19), Reeve (34), and Simroth (38)] to this slug having been found in cellars in other countries, but neither my predecessors Clarke (3) or Thompson (43), nor myself, have ever met with it in the house. I have found *L. maximus* in my own garden in Dublin, and in the country everywhere, chiefly in woods, under stones and tree trunks, and near the sea-shore, almost within high-water mark, but always locally.

Food.—Simroth (38) observes that the spirit in which specimens of *L. maximus* have been killed is never coloured green. He found that plants containing chlorophyll were always refused, whilst fungi were greedily devoured, and form the staple food of these slugs. When found in the cellar they may also live on meat or the juicy stalks of vegetables.

My experience almost agrees with that of Simroth in the above. The specimens which I kept in captivity only once gnawed at the green leaf of a *Campanula* after having received no other food for a week.

This species, like many others, occasionally exhibits a strong tendency towards cannibalism. It appeared to me that, especially where one specimen became rather sickly, the others would seize upon it and devour it.

Quite recently Gain (10) published some very interesting observations on the food of slugs. He says—" *L. maximus* is a very dainty feeder, preferring fungi to all other foods, and it seems to be harmless in the garden." Kew (17) writes on the same subject, "This species feeds freely on bread, and it also ate *Russula emetica*, but ripe berries of *Solanum dulcamara* were refused."

General Distribution.—Great Britain, throughout Continental Europe and

Asia Minor; also the islands of Sicily, Corsica, Sardinia, Azores, Madeira, and New Zealand (introduced), and East Coast of North America (introduced).

***Limax flavus*, L.**

Limax flavus. Linné, *Syst. Nat.*, 1758. *Limax variegatus*—Draparnaud, *Table Moll.*, 1801. *Limax flavus*—Jeffreys' *Brit. Conch.*, 1862.

(Plate LVI., fig. 3.)

Colour of body, lemon or orange-yellow spotted with gray, the spots being arranged in bands. Tentacles bluish. The intestine has a cæcum, but there is no flagellum.

Synonymy.—The name "*variegatus*" of Draparnaud (5), adopted by Moquin-Tandon (26), Simroth (32), and others, is not correct by the law of priority. Lessona and Pollonera (21) have pointed out that we cannot remain in doubt about the identity of Linné's species with that of Draparnaud, as the former refers to Lister's (22) figure, which is unmistakable.

External Characters.—The species is very constant in its external characters. This slug appears to be of a uniformly lemon-yellow colour; on closer inspection, however, we find that the yellow is obscured to such an extent by a delicate gray, especially on the mantle, that it seems as if there were yellow spots on a gray ground. Towards the sides of the body and mantle the colour becomes more of an orange. Specimens taken in my own cellar were more vividly coloured; they were always of a deep orange-yellow. But the yellow colour in this slug is entirely due to an abundant mucus, covering the body at all times. When it is wiped off, the true body-colour is revealed, which is a dull flesh tint. Although the secretion from the dermal glands of the back is so intensely yellow, the ordinary mucus of the foot is colourless and very abundant.

The tentacles present a very striking character, being of a delicate blue colour. They are shorter and thicker than in either of the two other species of *Limax*. But the wrinkles are, perhaps, the most characteristic feature in this slug. They are closely set, and have been likened by Simroth (38) to strings of pearls (perlschnurartig).

The largest specimen I have seen was 80 mm. long, by 10 mm. broad; so that it is considerably smaller than the preceding species, but rather broader for its size. Altogether, it is more rounded than *L. maximus*, and there is only a faint indication of a keel at the tail end of the body.

Only once have I seen a specimen which exhibited a trace of a band on one side of the mantle, but never on the body.

Anatomy (Plate LVII., fig. 26).—There are the same six convolutions of the intestine as in the preceding species, but *L. flavus* is distinguished from it, and resembles the next species, in having a blind process or cœcum attached to the end portion of the intestine. This remarkable feature induced Simroth (38) to unite *L. variegatus* (= *flavus*) and *L. arborum* (= *marginatus*) into one sub-genus. This author informs us that Selenka had discovered the presence of the cœcum; however, Nunneley (31) described it thirty years before him. The latter mentions that this cœcum consists of but little more than delicate cellular tissue, that it is always collapsed, and that the contents of the intestine do not pass down it.

The hermaphrodite gland (*hg.*) is not so elongated as in *L. maximus*, and is of a light yellow colour, but the shape of the gland naturally varies very much, and is therefore not of importance in the diagnosis of the species. The ovisperm duct (*os.*) seems rather shorter than in *L. maximus*; and the receptaculum seminis (*ree.*) is larger, and opens into the lower portion of the oviduct (*ov.*)

Reproduction.—The eggs of this species are at once recognized as distinct from those of *L. maximus*. They are provided with a minute sharp point at each end of the longer diameter. Those I examined were 7 mm. long., and 5 mm. broad; but, according to Simroth (38), they vary considerably in size, he having found some measuring 11 mm. long. They are somewhat yellowish in tint, and rather firmer in consistency than those of *L. maximus*. I found them at the end of November in an old tree trunk near Dublin, and the young slugs emerged a few days later. These young ones are much darker than the adults. They are of a somewhat greenish colour, and many of them had a very distinct light stripe running down the back, the sides being darker; otherwise they resemble the adults so much that there is no difficulty in recognizing the species at once.

In the cellars, where this species is common, I have obtained adults up to November, but in December not a single adult was seen. They must have died off, young and half-grown specimens being numerous. The fact of there being half-grown ones in December also proves that a deposition of ova takes place in the early months of summer.

Habitat.—*L. flavus* lives chiefly in cellars and kitchens, but it is by no means scarce in the country. I have often taken it in woods under the bark of old trees, along with *L. maximus*—always a number of them together. In Germany it seems to be almost exclusively confined to cellars.

Taylor and Roebuck (42) report its occurrence at Waterford, whilst I have taken it everywhere in the county Dublin; and Thompson (43) records its presence in the North. I have also received specimens from Mr. Barrett-Hamilton from Wexford.

Food.—Clarke (3) states that he kept specimens in confinement on bread, which they eat voraciously. I tried them with campanula leaves, but they would not touch them. Gain (10) found that they eat the stalks of cabbage and lettuce, raw and cooked potatoes, turnips and fruits, but that their favourite food is cream. Of foliage they took only the holly (*Ilex aquifolium*) at first, but he induced them later on to take leaves of the bean plant, bryony (*Bryonia divisa*), *Campanula latifolia*, and others. I have once found them feeding on a large fungus, and as they never colour spirit green, I have no doubt that Simroth (38) is right in concluding that their natural food consists in non-chlorophyllaceous substances.

General Distribution.—Great Britain; throughout continental Europe and Asia Minor; also the islands of Sicily, Sardinia, Madeira, the Azores, and Balearic Isles. It occurs also, but has probably been introduced, on the east coast of North America and Brazil, as well as in Australia and New Zealand.

***Limax marginatus*, Müller.**

Limax marginatus, Müller, *Hist. Verm.*, 1774. *Limax arborum*, Bouchard-Chantreaux, 1838, *Cat. Moll. Terr. et Fluv., Pas-de-Calais*. *Limax arborum*, Jeffreys, *Brit. Conch.*, 1862.

(Plate LVI., fig. 4.)

Body gelatinous, only slightly keeled towards tail. Colour, generally a reddish gray; dark lateral bands on body, continued to the front of mantle. Tentacles short. A cæcum in intestine, and a flagellum attached to penis.

Synonymy.—Jeffreys (16), in his text-book, seems to take it for granted that the species described under the above name by Müller (28) is identical with Draparnaud's (5) *marginatus*, although Draparnaud himself did not feel certain, on account of its different habits. What Draparnaud described was either the *Amalia carinata* (Leach) or a closely allied species; for, whilst Müller distinctly mentioned that his species inhabits the beech, Draparnaud's is a ground slug, and never ascends trees.

External Characters.—I have already mentioned that the lateral lyre-shaped bands on the mantle are a most typical character. In very dark specimens these bands may almost disappear; but I have never seen one in which they could not be recognized. The bands alone are sufficient to distinguish this slug from *L. maximus* and *L. flavus*. Moreover, it is distinguished from all other slugs by its gelatinous appearance, and the slightest touch will cause it to give off a most abundant watery mucus. It never grows to the size of *L. maximus*, with which, by the uninitiated, it might be confounded. The largest specimen I have seen measured 80 mm.

The general body-colour is a reddish or sometimes a bluish gray, which may be more or less obscured by darker bands or spots. In almost all cases a lighter stripe is left, which runs along the middle of the back. The posterior third of the body is carinated, but the keel is not nearly so marked as in *L. maximus*. The ground-colour of the mantle is as a rule lighter than that of the body. The middle portion is gray, and bordered on each side by a strip of light ground colour. The dark lateral bands almost surround the whole, although they do not quite meet in front or behind. The head is reddish gray, but it is also subject to slight variation in colour. The tentacles, as has been remarked before, are about half as long as those of an equal-sized specimen of *L. maximus* (fig. 2), and are somewhat similar in tint.

Anatomy (Plate LVII., fig. 27).—The interior of the body-cavity, especially posteriorly, is darkly pigmented. The intestinal convolutions are similar in number and shape to those of the preceding species, and there is also a cœcum. The hermaphrodite gland (*hg.*) is smaller than in the two other species of *Limæx*, generally dark in colour, and often divided into two portions. The ovisperm-duct (*os.*) is thick and short. The sperm-duct (*sp.*) and penis (*p.*) very short, the latter being distinguished by the presence of a flagellum (*fl.*) which may be looked upon as an accessory gland. The receptaculum seminis (*rec.*) opens, as in *L. maximus*, into the lower portion of the penis.

Reproduction.—I kept a number of specimens of this species in captivity from September until December. Eggs were deposited from the end of September till the middle of October, on an average about twenty in a cluster. The sizes varied somewhat, but they were mostly $5\frac{1}{2}$ mm. long by 4 mm. broad, and were extremely like those of *L. maximus*—very transparent and elastic. The young made their appearance exactly four weeks after the deposition of the eggs, and were of a reddish-violet colour throughout. Even at this stage, from the very first day of their birth, they are easily distinguished from *L. maximus*. The tentacles are about 2 mm. long in the latter, while in *L. marginatus* they are only 1 mm. in length. The young *L. marginatus* is born with the lateral bands fully developed, reaching right to the front, whilst in *L. maximus*, as we have seen, they stop short at the posterior third of the mantle. The bands on the body of the young, as Simroth (38) has pointed out, are not equivalent to those in *L. maximus*. In fact, they are not the real lateral bands (Stammbinde), but the inner bands, which appear much later in *L. maximus*. As I found a large number of specimens in September, measuring from 30 to 40 mm., we may conclude that in this species also there must be a deposition of ova at least twice in the year. Simroth (32) believes that this species lives through several years, but I venture to think that more evidence is needed to support this opinion.

Habitat.—*Limæx marginatus* has a wide range in this country. Both

Thompson (43) and Clarke (3) found it common in the North, on the stems of trees after rain. Taylor and Roebuck (42) report its occurrence from Kerry, Waterford, and other counties. Forbes and Hanley (9) state that they found it plentifully on bare rocks at an elevation of above 1500 feet near Connor Cliffs, above Dingle, in Kerry. It is a very common form around Dublin, but it is peculiar to the open country, and not found in gardens. It is seen both on the trunks of trees and among rocks, and under stones. The Rev. A. H. Delap sent me specimens from the Skelligs Rock agreeing in every respect with the mainland forms. This is a large bare rock, about ten miles from the coast of Kerry. Neither bush nor tree grows on it, and in westerly winds it is enveloped in a mist of spray, the waves beating over the greater part of it. From the Aran Islands in Galway Bay, which are quite bare and rocky, I have also received specimens, and, no doubt, this species occurs on all the islands along the west coast.

Food.—According to Lehmann (20) this slug is both carnivorous and herbivorous, but Simroth's (38) experience goes to show that it only touches animal food when driven by stress of hunger. He also states that the spirit is coloured green, not by the chlorophyll of leaves, but by that contained in lichens, and that the latter constitute the real food of *L. marginatus*.

This is very much my own experience. My captive specimens refused to touch green leaves or fish, and after four weeks they died from starvation. Although these observations are of some importance in establishing the nature of food which slugs live on, further experiments are needed to decide beyond doubt what the natural food of *L. marginatus* consists in. Gain (10) states that the specimens which he kept in captivity would not touch mosses, lichens, or fungi. This may be due to an unsuitable kind of lichen having been chosen, or else that the slugs were, for some reason or other, unwilling to feed at all.

General Distribution.—Great Britain, and the greater part of continental Europe; also the islands of Iceland and Sicily.

GENUS II.—*Agriolimax*. (Malm, 1868.)

Animal keeled only posteriorly. Mantle concentrically striated, the centre of striae being somewhat to the right of median line. There are no bands, and if spots are present they are irregularly scattered over the body. Pulmonary opening behind middle of mantle, and genital pore near tentacles. The intestine has four convolutions, and there is a solid internal shell; no caudal gland.

This genus includes some species which used to form part of the genus *Limax*, and in most modern text-books they are still retained under that denomination. Of course it is much better not to give up an old well-known name too readily; but a large number of species have been found in recent years in various parts of

Europe which may, with our two species, *A. agrestis* and *A. laevis*, be united into one group, differing in many important features from the genus *Limax*. The name *Agriolimax* has been adopted by such authorities as Simroth (38), Lessona and Pollonera (21), and Malm (25), although it is not by all of them used in the same sense. I have adopted Simroth's definition of the genus. The differences in the intestine alone are sufficient to separate the two forms *A. agrestis* and *A. laevis* from the Limaces, but there are additional and not less important differences. *Agriolimax* has only four convolutions of the intestine instead of six, and these four are altogether different in position from those in *Limax*. In the last genus the left lobe of the liver formed the apex of the intestinal sack; in *Agriolimax* it is the right. The reproductive organs do not show any very important difference in the two genera, with the exception, perhaps, of the retractor muscle of the penis. The chief objection to the more general recognition of this genus among Malacologists seems to be in the difficulty of fixing a constant character by which *Agriolimax* may be distinguished from *Limax* externally. Simroth (38), however, has shown, in his excellent monograph, that the species of *Agriolimax* never at any period of their lives possess bands. If in some varieties the irregular concentrations of dark pigment here and there appear to produce a kind of lateral band, we must not be led astray by appearances. In the genus *Limax*, on the other hand, lateral bands are always present, at any rate during youth. They may in later stages unite or break up into irregular spots, but in almost all cases their presence can be easily demonstrated.

The food in *Agriolimax* is different from that of the Limaces. As we have seen the natural diet of the latter is probably fungi and lichens, but *Agriolimax* lives on the higher phanerogamic plants. It is a most destructive pest in the field and garden, whilst the Limaces are comparatively harmless; indeed, they might even be called useful slugs.

SYNOPSIS OF THE IRISH SPECIES OF AGRIOLIMAX.

- I.—Mantle about one-third the length of body. Mucus milky = *A. agrestis*.
 II.—Mantle about one-half the length of body. Mucus colourless = *A. laevis*.

Agriolimax agrestis, L.

Limax agrestis. Linné, *Syst. Nat.* 1758. *Limax agrestis*, Jeffreys, *Brit. Conch.* 1862. *Agriolimax agrestis*, Malm, *Limacina Scandin.* 1868.

(Plate LVI., figs. 5 and 6).

Body-colour generally of a yellowish-white, irregularly spotted with gray, sometimes of a uniform gray or brown; mantle about one-third the length of body. Slime milky. A cœcum in intestine.

External Characters.—As a rule *Agriolimax agrestis* may be distinguished from *A. laevis* by the colour alone. The former is almost always of a dirty yellowish-white colour (fig. 5), either with or without diffuse patches of a darker pigment. The latter may altogether obscure the original body-colour, and produce a bluish slate-coloured slug (fig. 6). I have had two specimens from the Aran Islands, county Galway, which resembled *A. laevis* in so far as they were of a dark chocolate colour, but the milky slime, the short mantle, and the more pronounced keel were sufficient to pronounce them as mere varieties of *A. agrestis*. Anatomically they differed in no way from the usual form.

A. agrestis grows to a much greater size than *A. laevis*, the largest specimen measuring 40 mm. by 5 mm. According to Moquin-Tandon (26) it reaches the length of 60 mm. in France.

In a fully extended specimen the mantle occupies exactly a third of the total length of the body, which is somewhat compressed posteriorly, and there is a well-marked keel reaching from the posterior third to the end of the body. The head and tentacles are faintly violet-coloured, but vary according to the general body tint.

Quite fifty per cent. of the varieties I picked up during the summer in the country near Dublin were of a uniform yellowish-white, the space between the wrinkles being marked by a very light gray, so that the shape of each body-wrinkle was well seen. Once I obtained a perfectly white albino specimen under a heap of hay at Raheny. In November 60 per cent. of the *A. agrestis* in my garden were of a yellowish-white colour, faintly speckled with gray. On the other hand, of those obtained at the same time from the Aran Islands, 80 per cent. had the ground colour reddish-yellow, but they were uniformly mottled with dark gray, two specimens being almost black. The mucus in this slug is very abundant, and of a milky colour.

Anatomy. (Plate LVII., fig. 28).—There are only four convolutions in the intestine of this species and the next, as has been shown by Nunneley (31), and more recently by Simroth (38). But Nunneley did not notice the small cæcum near the terminal convolution of the intestine. Simroth pointed out that it is not homologous with that in *Limax*, being differently situated. The hermaphrodite gland (*hg.*) is elongated, and generally the acini composing it are split up like a bunch of grapes. The hermaphrodite duct (*hd.*) is almost always straight, *i. e.* not convoluted like that in *Limax*. Close to the genital pore, the ovisperm-duct (*os.*) divides into oviduct (*ov.*) and sperm-duct (*sp.*). The latter is short and opens into the very large penis (*p.*). The receptaculum seminis (*rec.*) is placed at the junction of the penis and oviduct. Near the opening of the sperm-duct into the penis, an accessory gland, the flagellum (*fl.*), opens into it also, and I found this to vary somewhat in the different specimens I examined.

A Paper dealing with the anatomy and histology of the alimentary canal and the nervous system has recently been published by Dr. Hanitsch (12).

Reproduction.—The eggs are globular and perfectly transparent, measuring 2 mm. in diameter. The specimens I kept in captivity produced only about 30 eggs each, but according to some authorities the same slug may deposit a large number during a short period. Thus, Moquin-Tandon (26) mentions that one specimen has, at different times, produced as many as 300 or even 350 eggs; and, according to the same authority, Leach is stated to have observed two slugs deposit 776 eggs. Although, no doubt, this slug is extremely prolific, I venture to think that further experiments are needed to confirm these observations. The young do not seem to me to present any appreciable differences from the adults.

I have taken specimens with fully developed reproductive organs from March to December. In the latter month and January the large specimens seem to die off, but it is difficult to determine their length of life. Simroth (38) believes that they live only one year.

Habitat.—*Agriolimax agrestis* is to be met with everywhere. It is the commonest, and probably the most destructive of all slugs. The damage done by it in the garden as well as in the field is enormous. It begins its ravages in the evening soon after sunset, and feeds the whole night through until the morning, when it retires for the day into worm-burrows or underneath stones and clods of earth. It seems to be little affected by weather or climate, being equally common on the islands of the west coast, on the mainland, and on the continent of Europe.

This slug is very active, and when touched, it glides through the fingers, leaving a mass of milky slime behind, and rapidly crawls away. As I have mentioned, I have seen the very dark variety only from the Aran Islands. The dark slate-coloured variety, described by Clarke (3), only once occurred to me along the high road to Whitechurch, near Dublin, and there were plenty of them on the spot.

Food.—*Agriolimax agrestis* is very voracious and omnivorous, but I think green food is preferred. In captivity they seemed to relish anything they were offered, and in this respect they are very different from most other slugs. In the garden I found them chiefly injurious to peas. They will eat the young shoots and the flowers, and even devour the pods. I doubt whether they do much damage underground to bulbs, which are chiefly preyed upon by *Amalia carinata*.

General Distribution.—Great Britain, and throughout continental Europe, Asia Minor, Persia, Siberia (?), Japan, Iceland, Greenland, the Azores, Madeira, Marocco. It has probably been introduced on the east coast of N. America, in Brazil, South Africa, and New Zealand.

Agriolimax laevis, Müller.

Limax laevis. Müller, *Hist. Verm.*, 1774. *Limax brunneus*. Draparnaud, *Table Moll.*, 1801. *Agriolimax laevis*. Lessona and Pollonera, *Monogr. Limac. ital.* 1882.

(Plate LVI., fig. 7.)

Body of a purplish brown colour. Mantle about one-half the length of body. Slime watery. Intestine without a cœcum.

External Characters.—This slug has not been recorded before from Ireland. It was discovered by Mr. Rathborne in Lord Massy's estate at Killakee, near Dublin, and brought to me for identification. I shortly after found two additional specimens in the same place, *i.e.* along the banks of an old fish pond. Unfortunately none of the specimens were full grown, but I at once distinguished it, as I had expected to find it before, it having a very wide distribution, ranging all over Europe and America.

The best description which I have seen of this slug is that by Heynemann (14). According to him *A. laevis* differs chiefly from the closely allied *A. agrestis* by the size of the mantle, which is almost one-half the total length. The back is only very slightly keeled towards the end of the body, which is of a dark purplish brown colour throughout. Simroth states that younger specimens are of a dark gray, but those I found which only measured 3 mm. and 10 mm. respectively were precisely the same in colour as the largest which measured 15 mm. Its maximum length, according to Heynemann, never exceeds 20 mm. (about three-quarters of an inch), so that it is the smallest of our native slugs. The neck can be stretched out very considerably. The mucus is perfectly clear and transparent, by which the species can perhaps most easily be recognized.

The shell, especially in younger specimens, is often visible through the mantle, and its outlines are indicated by a golden yellowish colour.

Anatomy (Plate LVII., fig. 29).—All the specimens I found being immature, the reproductive organs were not fully developed. The intestine is similar to that in the last species, but the cœcum is entirely wanting. The largest specimen, measuring 15 mm., which I dissected, had only the female reproductive organs developed. This agrees with Simroth's (38) observations, who found that the female portion of the generative organs was generally developed before the male portion. The hermaphrodite gland (*hg.*) is dark, the rest of the reproductive organ being much the same as in *A. agrestis*, with the exception perhaps of the penis, which, according to Simroth is hammer-shaped, the flagellum being of a very different shape from that in *A. agrestis* (32 Plate ix., fig. 17).

Reproduction.—I have not observed the eggs of this slug. Simroth (38) tells us that they are about the same size as those of *A. agrestis*, measuring between 1.25 mm. and 2 mm. in diameter. Moquin-Tandon (26) states that in *Limax brunneus* Drap (= *A. laevis*) the eggs are $1\frac{1}{2}$ mm. long and 1 mm. broad, and that the number at each deposition varies from twelve to eighteen. Simroth found young at all seasons, but does not give an opinion as to the limits of age in this species, and my own observations are so limited that I cannot venture to express an opinion.

Habitat and Food.—In Ireland this species seems to be very local, and it certainly never occurred to me in company with *A. agrestis*. In Germany it is found along with *A. agrestis* in the garden and field, but everywhere it appears to prefer damp situations, being commonest near banks of rivers or in ditches.

Mr. Burbidge, of the Trinity College Botanic Gardens in Dublin, mentioned to me quite recently that a little black slug had appeared in his orchid houses. I managed to secure a specimen, and found it to be an *Agriolimax laevis*, and I ascertained that the sphagnum moss so extensively used in the cultivation of orchids was brought down to Dublin from the neighbourhood of Killakee, the only locality where I have met with this species.* It seems to thrive in the warm orchid house, and manages to do a good deal of damage to the delicate flowers. I have not been able to ascertain what food it lives on in its original home.

General Distribution.—Great Britain, and throughout continental Europe; Siberia, and throughout North America and Brazil.

GENUS III.—*Amalia* (Moquin-Tandon, 1855.)

Animal generally sharply keeled along the whole of body behind mantle. Mantle, which is shagreened or granulated, has a horse-shoe shaped groove. Body without bands. Pulmonary opening behind middle of mantle. Genital opening near base of tentacles. Intestine has four convolutions, and there are accessory glands in connexion with oviduct or vestibule. There is a solid internal shell, but no caudal gland.

This genus, like that of *Agriolimax*, has formerly been united with the genus *Limax*, and the various species of *Amalia* are found under the latter genus in such text books as Jeffreys (16) and Forbes and Hanley (9). In recent years the structure of slugs and their habits having become better understood, mostly owing to the labours of Simroth and of Lessona and Pollonera, the grouping under one genus of a number of miscellaneous forms has been discontinued.

Externally the Irish species are characterized by a sharp ridge or keel running along the whole of the back. In some of the Continental forms this keel does not seem to form such a prominent feature. A character which is applicable

* Since writing the above, I found this slug also in Connemara, county Galway, and at Killarney, county Kerry.

to all the species and by which the genus is most readily distinguished from others, is the deep horse-shoe shaped groove on the mantle. The mantle, moreover, is different from that in the two preceding genera in being granulated.

As regards the internal organization, the genus is more closely allied to *Agriolimax* than to *Limax*, but still there are many very important differences. There are four convolutions to the intestine in both genera, but *Amalia* has accessory glands in connexion with the vestibule or oviduct, which are absent in *Agriolimax*. On the other hand, the penis in *Amalia* has no accessory gland or flagellum. The sperm is transmitted by means of a spermatophore in *Amalia*, and by a soft mucous capsule (Schleimpatrone) in the other. *Agriolimax* is quick in its movements, has a delicate skin and abundant liquid mucus, whilst *Amalia* is slow, with thicker skin and often with tough viscid mucus.

SYNOPSIS OF THE IRISH SPECIES OF AMALIA.

I.—Colour generally brown, foot yellowish, and mucus viscid = *A. carinata*.

II.—Colour generally black, foot white, and mucus watery = *A. gagates*.

Amalia carinata, Leach.

Limax carinatus. Leach, *Synops. Moll. Brit.*, 1820. *Limax marginatus*. Jeffreys, *Brit. Conch.*, 1862 (not Müller.)

(Plate LVI., fig. 8.)

Colour of body generally brown. Groove on mantle almost always filled with dark pigment. Skin thick, and interstices between wrinkles filled with black pigment, and slime viscid. Keel of a lighter colour than rest of body. Foot yellowish. Receptaculum seminis very large and elongated.

Synonymy.—The name *Limax marginatus* applied to this slug by Jeffreys (16) has already been disposed of, having evidently been intended by Müller (28) for quite a different species. The name *L. marginatus* has been kept up by Taylor and Roebuck (42) in their Irish list, and in the *Conchological Journal* (41), but it has been discontinued for the British form by Continental authors, such as Simroth (38) and Lessona and Pollonera (21). I think there is no doubt that the Irish form is the one described by Leach (19) as *Limax carinatus*. I was not sure whether it was the same as the Continental, at least the German form, so I submitted specimens of several varieties to Dr. Simroth, who pronounced them to be *Amalia carinata*, Risso. He tells me they differ but little from the German specimens, hardly sufficiently to attach to them a distinct varietal name. The proofs of Leach's work (19) were in circulation in 1820, so that his name should be attached in preference to that of Risso.

External Characters.—*A. carinata* is at once distinguished from all the preceding species by the prominent ridge or keel running from the posterior margin of the mantle to the end of the body. A less conspicuous feature, by which this and the next species may be distinguished from all others, is the horse-shoe shaped groove on the mantle. In *A. carinata* this groove is almost always filled with a black pigment, so as to render it more readily visible than in the next species. Some authors have thought it advisable to create a separate name for specimens in which the black marking meets in front to form a complete horse-shoe. However, I have examined a large number of specimens from gardens in Dublin where it is, after *Agriolimax agrestis*, the commonest slug, and I found that in fully 20 per cent. the horse-shoe marking is complete, *i.e.* unites in front. In some specimens there was only a faint indication of any marking at all; in fact, it is a feature which is not by any means constant. I noticed also that in those 20 per cent. in which the black pigment extends all round the groove, the general body-colour is darker than in the others.

The body-colour in this species varies from yellowish brown to dark brown, the sides getting lighter towards the foot. The inter-space between the wrinkles is generally marked by darker pigment, and the mantle is granulated. The head and tentacles are of a bluish colour, sometimes purple, and the keel is almost always lighter than the body-colour on each side of it.

The largest specimen taken measured 65 mm. long, by 10 mm. broad. Moquin-Tandon's (26) *Limax marginatus*, which is probably this species, never exceeds 60 mm. in length in France.

Anatomy (Plate LVII., fig. 30).—There are the four convolutions of the intestine as in *Agriolimax*, but without a cæcum. The upper portion of the reproductive organs are like those of *Agriolimax*, but in the lower parts, important differences appear. The receptaculum seminis (*rec.*) is very large, equalling the free oviduct (*ov.*) in length. Its lower part is wide, but it becomes attenuated in its upper portion. What appears to be the penis is in reality the portion of the sperm-duct in which the spermatophore is formed (*pat.*); the lower portion only can be looked upon as a penis (*p.*). Both penis and oviduct, as well as the receptaculum, open into a short vestibule or atrium (*lv.*) which, according to Simroth (38), is everted during copulation. A number of large accessory glands (*ac.*) also open into the vestibule by means of delicate ducts.

Reproduction.—The fact that hardly any of the text-books referred to, give a description of the eggs of this species shows that they have rarely been observed. Although I kept a large number of specimens in captivity from the middle of September to the end of the year, none of them deposited eggs. Simroth (38) is the only author who refers to the ova of *Amalia marginata*, which is either the same or a closely allied species to ours. He states having observed them at the end

of March, and that they measure 6 mm. by 5 mm. They are, therefore, about the size of those of *L. maximus*, and very much larger than one would expect. I have met with a good many specimens of the slug, about 15–20 mm. long in July, so that the deposition of eggs in Ireland probably takes place in April or May. The young ones do not differ to any appreciable degree from the adults. I saw no half-grown or young specimens during winter, so that at any rate the reproduction of this form seems to differ from that of most other slugs, and in all probability it lives for more than one year.

Habitat.—Simroth gives limestone rubble (kalkgeröll) in mountainous districts as the abode of the *A. marginata*. The habitat of our *A. carinata* is totally different. It is one of the commonest garden slugs in Dublin. It is very gregarious, and one often finds a number of them close together in worm-burrows, or at the root of delicate plants. They are, like all slugs, fond of stiff clay soil, which keeps the moisture so much longer than sandy soil, and which, owing to the numerous worm-burrows, gives them better shelter. They spend the day underground, and come out at night in damp weather, but they often drag bits of stalks underground to feed on at their leisure. In the open country I have met with them everywhere, but only locally. They are widely distributed. Miss Warren tells me that this species is rare in Sligo, whilst *A. gagates* is common, but I have received a large number of *A. carinata* (rather dark ones) from the Aran Islands, county Galway, and it probably occurs everywhere in the West. These did not differ anatomically from our Eastern forms. It seems surprising that Clarke (3), who was such an authority on slugs, did not meet with this species in the North of Ireland, and only records it from Dublin, whilst Thompson (43) gives Monivea and Clifden in county Galway, and Cork, as the localities where it occurred to him.

Food.—Simroth (38) believes that the German species of *Amalia* are carnivorous. Although the Irish *A. carinata* is carnivorous at certain times, it is generally a most determined vegetable feeder, and, I believe, runs *Agriolimax agrestis* very close in being the most voracious and destructive of slugs.

As I mentioned before, I have had specimens in captivity for several months, and I have had good opportunities for observing its habits in the garden. I find that it is especially fond of leaf stalks and bulbs, but it greedily devours green leaves. The bulbs and stalks seem to suit them better when they are stale and beginning to decay. Of the thirty or forty which I kept in a large tin box filled with earth, and always supplied with leaves, bulbs, &c., about a dozen were eaten by their companions, only the shells being left. Observing them very closely, I noticed that only weak specimens, which seemed either old or seized by illness, were devoured.

The more vigorous ones always spent the day underground, burying themselves several inches deep. In the garden I noticed that many bulbs in heavy soil

entirely disappear. This would be commonly attributed to the nature of the soil, but it is really due to the depredations of *A. carinata*. I find that in sandy soil bulbs are less liable to be attacked by this species. Gain (10) states that *A. marginata* (= *carinata*) took most of the different kinds of foods offered. I hope this writer will publish a more detailed account of the nature of the food offered than what has hitherto appeared.

General Distribution.—Great Britain, Germany, Switzerland, France, Austro-Hungary, Greece, Italy, Spain, and Portugal.

***Amalia gagates*, Drap.**

Limax gagates, Draparnaud, *Table Moll.*, 1801. *Amalia gagates*, Heynemann, *Mal. Blätter*, 1861. *Limax gagates*, Jeffreys' *Brit. Conch.*, 1862.

(Plate LVI., fig. 9.)

Colour generally dark lead or light drab brown. Keel of nearly the same colour as the rest of body. Interspaces between wrinkles and groove on mantle without black pigment; foot white, and slime watery. Receptaculum short and round.

External Characters.—As I have stated in the synopsis, this slug is distinguished from *A. carinata* by its colour, which is black, or, more correctly, dark lead. There is also a brown variety, but even then the two species are readily distinguishable. In *A. carinata* the brown is always richer, being either a deep rich brown or a bright yellow-brown, while in the variety of *A. gagates* it is always a light drab-brown. Besides, the foot is always pure white, the skin delicate, and the mucus watery. In *A. carinata* the foot is yellowish, the skin is thick, and the mucus tough and sticky. Both species may be distinguished merely by the touch. Whilst *A. carinata* feels like a sticky lump of fat, *A. gagates*, owing to its more watery mucus, glides readily through the fingers.

In this species the horse-shoe shaped groove on the mantle is well marked, but there being no black pigment, it is not so apparent as in the preceding one.

The mantle in *A. gagates* is almost of the same size as the body, whilst in *A. carinata* it is only about three-fourths of the length. The keel in *A. gagates* is much sharper than in *A. carinata*, and the interspaces between the body-wrinkles have no black pigment, which in *A. carinata* gives it the speckled appearance.

The largest specimen I have seen measured 50 mm. by 6 mm., showing that it is altogether smaller and more slender than the other *Amalia*.

Anatomy (Plate LVII., fig. 31).—Full-grown specimens measure about 30 mm. in

spirit. The various parts of the reproductive organs differ from those in *A. carinata*, chiefly in being much shorter. The sperm-duct (*sp.*), the "Patronenstreecke" (*pat.*), and the receptaculum (*rec.*) are all shorter, in comparison with the same organs in the preceding species. The receptaculum seminis (*rec.*) exhibits, perhaps, the most striking difference, being more rounded, with a short stalk. There is generally one accessory gland (*ac.*) opening into the vestibule, but sometimes there are more. I have noticed in a brown specimen as many as four, whilst in another from the same locality there was only one.

Reproduction.—The smallest specimens I have seen measured about 20 mm., and did not differ very materially in colour from the adults. A specimen kept in captivity deposited eight eggs at the end of August. They were very delicate and thin-shelled, adhering together by a glutinous mucus. They were slightly oval in shape, and measured only 2 mm. long by $1\frac{1}{2}$ mm. broad. It is surprising that there should be such a very great discrepancy between the size of the eggs in the two species of *Amalia*.

Habitat.—This species is one of the rarest of slugs; and I never found it but in the open country, and only at all abundant in one spot, at Raheny, near Dublin, in a field under heaps of decayed weeds. In the same place I obtained an occasional specimen of the drab-coloured variety among the others. Later on I found a few specimens at Kilruddery and Whitechurch, both near Dublin. I received two specimens from Miss Warren, who found them in her garden at Ballina, in Sligo; and a dark one from the Aran Islands, along with a number of *A. carinata*. Clarke (3), who first discovered this species in Ireland, states that in the Queen's County, at La Bergerie, the brown variety is much commoner than the black. He has taken the slug also in the counties of Galway and Mayo, it being very abundant in the latter.*

Food.—Gain (10) states that this species took 83 per cent. of the different kinds of food which were offered. I have not myself observed what it lived on, but it seems probable that its chief natural diet consists in decaying plants.

General Distribution.—Great Britain, France, Italy, Spain, Portugal, Sicily, Sardinia, the Balearic Isles, Egypt, Algiers, Morocco, the Azores, Madeira, St. Helena, Ascension, South Africa (?), California (?), Bermuda, and, probably introduced, in Brazil.

GENUS IV.—*Arion* (Férussac, 1819).

Body, nearly cylindrical, strongly wrinkled. Mantle, shagreened or granulate. There is a caudal gland. Internal shell, not solid, but composed of a soft mass of granules. Pulmonary opening in front of middle of mantle, and genital pore

* I have since taken it at Queenstown, county Cork.

situated close to it. There never is a well-marked keel except in young specimens. The intestine has four convolutions.

The most apparent characteristic by which this genus may be distinguished from the preceding ones are the presence of a caudal gland, and the fact of the respiratory opening being situated in front of the middle of the mantle.

The caudal gland is easily visible externally (Plate LVI., fig. 10). Its opening is situated at the very end of the body, and is triangular in shape; the base of the triangle being directed towards the head.

Another, perhaps, less noticeable feature is that of the reproductive pore, which lies quite close to the respiratory opening, whilst we have seen that in the other genera it is situated near the tentacles.

The mantle, or shield, in *Arion* is granulated as in the genus *Amalia*.

All the species of *Arion* are altogether broader in shape than any of the slugs hitherto considered.

There never is, in *Arion*, a well-marked keel, and though we may, as in young *Arion hortensis* and *A. bourguignati*, have slight indications of one, it is nothing like what obtains in *Limax*, *Agriolimax*, or *Amalia*. The wrinkles are generally more prominent in *Arion* than in the other genera.

As regards the internal structure of the genus *Arion*, I may mention in the first place that there is no solid shell, but a soft mass of calcareous granules, which, in some of the smaller species, may be somewhat firmer than in the larger ones. Simroth (38) has pointed out, that whilst *Limax*, *Agriolimax*, and *Amalia* utilize their male end-organs during copulation, in *Arion* the female end-portions of the reproductive organs are used as penes. What is generally looked upon as the penis in *Arion* is no such thing, there being no retractor muscle to it. The enlarged end portion of the sperm-duct is used for the preparation of the spermatophore (sperm-case), and Simroth (38) has applied to it the term "Patronenstrecke" (cartridge-portion).

There are four convolutions in the intestine, the first being the largest.

SYNOPSIS OF THE IRISH SPECIES OF ARION.*

A.—Margin of foot with transverse striae = *A. ater*, *A. subfuscus*.

I.—Wrinkles keeled and elongated = *A. ater*.

II.—Wrinkles flat and short = *A. subfuscus*.

* It is very difficult to give good external distinctions for the species of *Arion*, but the above will be found fairly practical, if it be kept in mind that wrinkles are a variable feature and that slugs must be compared under similar atmospheric conditions.

B.—Margin of foot without transverse striae = *A. hortensis*, *A. bourguignati*,
A. intermedius.

I.—Foot coloured = *A. hortensis*, *A. intermedius*.

a. Wrinkles flat = *A. hortensis*.

b. Wrinkles with conical spikes = *A. intermedius*.

II.—Foot white = *A. bourguignati*.

Arion ater, L.

Limax ater and *L. rufus*, Linné, *Syst. Nat.* 1758. *Arion empiricorum*, Férussac,
Hist. Moll. 1819. *Arion ater*, Jeffreys, *Brit. Conch.* 1862.

(Plate LVI., figs. 10–16).

Colour very variable, but generally either brown, black, or red, in adults; and either light red or yellow in young ones; wrinkles very long behind middle of mantle, and sharply keeled. Foot generally yellowish, but never white; head and tentacles dark violet.

Synonymy.—Many Continental authors have adopted for this species Férussac's (8) name of *A. empiricorum*, chosen by him because he thought a new name would avoid the confusion arising from Linné's adoption of two designations, viz. "*ater*" and "*rufus*" for varieties of the same species. According to the British Association Code of Rules, however, which is observed by British zoologists, the oldest name or the one standing first on a list shall be used, irrespective of the suitability of the name.

External Characters.—This species is the most variable of our Irish slugs. During youth the number of variations are much larger than in adults, as they almost all darken with age, becoming more uniform in colour.

In Ireland I have up to now met with six very distinct varieties of the adult slug, viz. brown, black, claret-red, salmon-red, olive, and black with yellow sides. In some of these the foot may remain unaffected by the colour, whilst in others the foot becomes more or less coloured too, but I think that is not a point of any importance. The brown variety (Plate LVI., fig. 10) is perhaps the commonest (in the gardens about Dublin, at any rate).

The margin of the foot, in all these varieties, is transversely striated, by which character this slug may be distinguished from all other species of *Arion* except *A. subfuscus*.

The wrinkles are useful in discriminating between *A. ater* and *A. subfuscus*.

In the former the wrinkles on the back, just behind the mantle, are very long, and sharply keeled, whilst in *A. subfuscus* they are hardly half as long, and flat.

Too much importance, however, should not be attached to the shape of the wrinkles. Anyone who has kept this species in captivity can see for himself that, by carefully sprinkling the box in which the specimens are confined with water, the body-wrinkles after a while become more and more flattened out. A specimen which may have had all its wrinkles standing out sharply from the body, in a dry atmosphere, appears quite changed after it has been imprisoned in a damp tin box for a couple of hours. There are naturalists who have manufactured new species of *Arion* merely by the different shapes of the wrinkles; but a little practical observation shows how much they are worth. An adult of *A. ater* cannot be mistaken for *A. subfuscus*, but a young one might, and indeed has been by most writers. A rough and ready method of discriminating between the two species is to give them a tap on the head. *A. ater* will almost immediately draw itself together, and resting on its foot, the arched body will appear nearly equal in length and breadth (Plate LVI., fig. 11). Another tap now will, in almost every case, even in very young specimens, cause the animal to rock about from side to side. This most peculiar motion, which is often continued for several minutes, has never, to my knowledge, been observed in any other slug. A similar tap applied to *A. subfuscus* will merely cause the animal to shrink up, but it will never assume the characteristic hunched position of *A. ater*, nor will any tapping produce the swaying movement.

The margin of the foot is very often of a colour different from the rest of the body; thus in brown specimens the margin may be brick-red. On the Continent specimens of a similar brick-red tint covering the whole body are extremely common, and in central Europe the large majority are of this colour. (This will be referred to again in the Chapter on Colour.) I have never seen an adult brick-red specimen in Ireland.

The head and tentacles are, as a rule, of a dark violet colour. There is no trace of a keel, the back being perfectly rounded.

This species assumes much larger proportions on the Continent than it does in Ireland. The largest I have seen near Dublin measured 90 mm. by 10 mm. On the West Coast specimens of that length, but rather broader, are common. The average size for a full-grown specimen on the East Coast, however, is 60 mm. by 10 mm.

The nature of the mucus varies in proportion to the severity of the stimulus. As a rule colourless, it becomes orange-yellow when the animal is much irritated, and sometimes I have seen it milky like that of *Agriolimax agrestis*.

Anatomy (Plate LVII., fig. 32).—Detailed accounts of the anatomy of this species have been given by Lawson (18), Nunneley (31), and others. I have

examined specimens from Norway and the different parts of Ireland, and find that there is less difference between the East Irish and Norwegian than there is between the West and East Irish.

The colour of the hermaphrodite gland (*hg.*), generally of a light brown, varies according to the colour of the body. The hermaphrodite duct (*hd.*) is well convoluted. The free oviduct (*ov.*) opens into a vestibule as in *Amalia*, but there is in *Arion ater* an additional glandular lower vestibule (*lv.*) which has by Lawson (18) been incorrectly named cloaca. The upper vestibule (*uv.*) or atrium he distinguishes as the "egg-sac."

The sperm-duct (*sp.*) ends in what used to be regarded as a penis, but which Simroth (38) has shown is only the enlarged lower portion of the sperm-duct (*sp.*) in which the spermatophores or sperm-cases are formed. The receptaculum (*rec.*) and the "Patronenstrecke" (*pat.*) of the sperm-duct (*sp.*) opens into the lower portion of the upper vestibule (*uv.*).

Both the oviduct (*ov.*) and the duct of the receptaculum are provided with powerful retractor muscles (*rm.*), which in West Coast specimens are attached quite close to the receptaculum and the upper portion of the oviduct, respectively, whilst in East Coast forms these same muscles are almost invariably attached much lower down to the same structures. Of course this alone may not be of much importance, but coupled as it is with differences in colour and length of life, the West Coast forms constitute what we may at present regard as a striking variety of *A. ater* which may become further modified in time. I propose to reinvestigate this form when I have collected more material in the West.

Reproduction.—The eggs are laid chiefly in August and September, in clusters averaging about fifty in number. I have frequently observed them in fields under heaps of hay and in gardens under stones. They are deposited freely in captivity. They adhere only very slightly to one another, and may be easily distinguished from any of those previously described by their remarkable hardness. They feel quite solid, and owing to their calcareous shells are perfectly opaque. They have a long diameter of 4 mm. and a short one of 3 mm.

I said above that reproduction takes place chiefly in August and September, but a few specimens, undoubtedly, deposit eggs earlier, for I have seen quite young ones in August, and as the eggs take about 4 to 6 weeks to develop, they must have been deposited in June.

Throughout the winter large numbers of young ones are to be met with in the garden, and frost does not seem to affect them very much. These young specimens (figs. 13 and 14) are invariably of a very light yellow or red—never dark. Generally well-defined black lateral bands run along each side of the body, and are continued on the mantle, ending at its anterior margin; and all have dark-coloured heads and tentacles. I have no doubt that these young forms, which are

about 30 mm. long in March, reach their maturity in the following autumn, and I quite agree with Simroth (38), who fixes the limit of age in *A. ater* at one year.

In the month of March the portion of the back and mantle between the lateral bands becomes darker, a condition which is well seen in figs. 11 and 12; and in that case a narrow light stripe is left between the dark portion and the bands. But in some cases the back darkens uniformly, producing forms which have been described by Roebuck as var. *bicolor* (fig. 15). I have found a half-grown form at Whitechurch, near Dublin, in which the back remained light, whilst the sides darkened (fig. 16). Similar young forms of the var. *bicolor* have been described by Simroth (38) from the shores of the Baltic, and it is remarkable that every instance of their occurrence is in close proximity to the sea. The light sides in these specimens remain light throughout life. At Raheny, near Dublin, where I have collected extensively last September, fully 30 per cent. were black above with yellow sides, the remainder being entirely black with olive margin at foot. All these had fully-developed reproductive organs. At Howth, Mr. Redding has taken them with brilliant orange sides (fig. 15). In both cases the specimens were found almost within reach of high tide. Only in one instance have I seen this variety further inland in several specimens which were kindly given to me by Mr. A. G. More, from his garden at Rathmines. This lies fully three miles from the sea, but it may be that they found their way to the gardens with plants from the sea-side.

This disposes of the *A. ater* from the East Coast of Ireland. On the West Coast the same species forms a very remarkable variety, possibly owing to the difference of the meteorological conditions. If we look at Scott's (37) latest report on the variability of the temperature in the British Isles, we find that during fifteen years in Valentia Island, the thermometer only descended below freezing point six times. In summer, during the same period, it only once rose above 70° F. (= 21° C.). There is in fact probably no place in Europe where such an equable climate exists as on the South-West Coast of Ireland.

As a result of these favourable meteorological conditions, adult forms of *A. ater* survive the winter, but apparently do not develop reproductive organs in that period. I received a large box of specimens, 80 mm. long, from the Aran Islands in November. Their body cavity was almost entirely filled with a huge liver and intestines, whilst the generative organs were like those of an ordinary half-grown specimen. Again, in May, I collected everywhere in the mainland of Kerry, and on Valentia Island, numbers of specimens considerably larger than our Dublin full-grown forms, but again with hardly a trace of any reproductive organ. Among these an olive-coloured variety is very common, and also one of a cinnamon-red; neither of these is banded. Besides these, rich brown forms, like

those on the East Coast, also occur. Those from the Aran Islands were almost all pitch black.

I only found two specimens with fully developed reproductive organs in my collection, and these were sent to me in August by the Rev. A. H. Delap, from the Skelligs Rock, off Valentia. Thus we probably have the same period of reproduction as on the East Coast, but the specimens either live for two years, or for a year and a-half. The latter seems to me more probable, and we should, in that case, have a second period of reproduction in the early months of spring on the West Coast.

Habitat.—This species is found everywhere in company with *Agriolimax agrestis*, both on the mainland and many of the islands on the West Coast. In the garden it is one of the commonest forms. In my own garden I have never seen an adult of any other colour than a rich brown (fig. 10). Similar brown slugs I have noticed as very abundant on the West Coast. In woods and fields near Dublin I have hardly ever seen this variety. In the Dublin Mountains, at Killakee, all the adult forms I obtained were of a dark claret colour; they resembled very much the fallen pine-needles that covered the ground, and it seemed to me a case of protective colouring.

On the West Coast I have collected at Calhirciveen, Derrynane Bay, and other places in the Co. Kerry, and most specimens were either brown or olive-coloured—sometimes of a salmon-red—and the ground being boggy, again resembled the colour of the slugs. It has been remarked by many observers, and it agrees with my experience, that this slug is more often seen crawling about in the daytime than others. I have especially noticed this fact on the West Coast, where, of course, the climate is exceedingly damp, but it struck me also in the forests of Germany, where one sees so many large red-coloured *A. ater*.

Food.—*A. ater* is undoubtedly a voracious vegetable feeder, preferring decaying chlorophyllaceous plants to fresh ones. I have kept them on campanula leaves for a long time. Kew (17) kept this species in captivity from May to October, during which time twenty-six different substances were eaten. One slug lived on a newspaper for some time. He says—"The dead bodies of *Arion subfuscus*, *A. hortensis*, *Limax maximus*, *L. flavus*, and *L. agrestis*, a dead *Unio*, freshly turned pupae of *Admonia tanacetii*, a small part of the abdomen of a dragon-fly (*Diplax striolata*), leaves of lettuce, *Scabiosa succisa* and *Solanum nigrum*, flowers of *Pedicularis sylvatica*, *Ranunculus flammula*, *R. acris*, *R. repens* and *R. bulbosus*, and the lichens *Evernia prunastri* and *Ramalina farinacea* were readily fed upon. *Polypodium vulgare*, *Eryngium maritimum*, and berries of *Arum maculatum* were taken in small quantities and with evident reluctance, as also was Pears' soap."

Thompson (43) noticed two specimens of this species busily engaged devouring a snail (*H. aspersa*) which appeared to be freshly killed.

We thus see that although *A. ater* is on the whole a vegetable feeder, it is not particular as to its choice of food, and is always ready to eat almost anything that comes within reach.

General Distribution.—Great Britain, and throughout continental Europe, Algiers (?), Azores (?), Madeira, and Iceland.

***Arion subfuscus*, Drap.**

Limax subfuscus, Draparnaud, *Table Moll.*, 1801. *Arion ater* (pars), Jeffreys, *Brit. Conch.*, 1862.

(Plate LVI., figs. 17–19.)

Colour either yellowish or light gray; never brown or black. The wrinkles short and flat. Margin of foot white, with gray transverse striæ. Thick yellow slime on body, chiefly near head and tail. Foot and sides of body generally white; sometimes yellowish.

Synonymy.—In such text-books as Jeffreys (16) and Forbes and Hanley (9) this species is grouped under the varieties of *A. ater*, although it had long before been described as a distinct form by Draparnaud (5). I believe that Müller's (28) *A. flavus* is an immature form of *A. subfuscus*, and not identical with Simroth's (38) *A. minimus*, the latter never growing longer than one inch, whilst Müller gives $1\frac{1}{2}$ inch as the size of his slug.

External Characters.—Three varieties of this slug are found near Dublin which, although they do not, as far as I have been able to ascertain, differ anatomically, show considerable external differences. We may, indeed, regard them as species in process of formation. I have had too few specimens to come to a definite conclusion, and further researches may reveal new characters by which they can be separated anatomically.

The typical *A. subfuscus* (Plate LVI., fig. 17) resembles *A. ater* in having the margin of the foot transversely striated, and in having a dark head and tentacles, which, however, are never as dark as those in *A. ater*. The sides are white, and have a semi-transparent appearance like a wax candle. The margin of the foot, and the foot itself is white, the former with delicate gray cross-bars. There is no variety of *A. ater* with a white foot or white sides, and this distinguishes the typical *A. subfuscus* at once. The upper surface is dark gray, becoming lighter towards the very distinct lateral bands. The whole of the back and mantle is almost always covered to such an extent by a thick reddish-yellow mucus, as to obscure the gray colour and make it appear reddish-brown. The mucus is most intense in colour on the anterior portion of the mantle, and near the caudal gland.

To show that this mucus has nothing to do with the real colour of the slug one need only wrap it up in a piece of blotting paper, and roll it about for a moment, when all the mucus will be soaked up. The slug then appears in his natural costume, which is composed of white and a bluish-gray, without any trace of a yellow or red pigment in the skin.

If we subject the two varieties (Plate LVI., figs. 18 and 19) to the same treatment we get a very different result. The first (fig. 18), which, by the way, is not the *A. brunneus* mentioned by Lehmann (20) and Simroth (38), has no lateral bands, but is rather darker on the back than at the sides. It is a yellow slug, but on the mantle we again find the peculiar reddish mucus, and if the latter is soaked up by blotting paper, we have an entirely yellow slug, and the yellow is due to a pigment investing the skin in small granules. Moreover, the space between the wrinkles is of a bluish colour. The second variety (fig. 19) is entirely yellow, with a lateral band on the back. The margin of the foot in both these varieties is yellow, the yellow colour extending also to one-third the breadth of the foot on each side.

I found the typical form of *A. subfuscus* generally between 40 and 45 mm. in length, whilst adults of the first variety were as a rule rather smaller, viz. 35 to 40 mm. Of the second variety I obtained only one specimen, whose reproductive organs, although not fully developed, showed that it was more nearly allied to *A. subfuscus* than to *A. ater*. Recent investigations into the anatomy of the *Arionidae* such as those of Pollonera (33) and Simroth (40) may throw light on the affinities of this species, which for the present I must regard as a variety of *A. subfuscus* more material is available. My specimen was 55 mm. in length.

The wrinkles in all these slugs differ from those in *A. ater* in being much shorter, which is especially well seen in the wrinkles just behind the mantle. They are much flatter than those in *A. ater*, although one has to guard against the influences of temperature in comparing these in different slugs, as I have had occasion to point out under the heading of *A. ater*. The slime is abundant and clear, and must be distinguished from the intensely yellow mucus which is until produced by the mucus glands on the back and mantle of the slug.

Anatomy (Plate LVII., fig. 33).—The internal organization of this species differs little from that in *A. ater*, but all the different parts, of course, are smaller. The ovisperm-duct (*os.*) is shorter in proportion than in *A. ater*. As in the latter there is no penis, the sperm-duct (*sp.*) ending in a "Patronenstrecke" (*pat.*) in which the spermatophores are produced. This portion opens into the lower part of the duct of the receptaculum (*rec.*), which, in its turn, opens directly into a lower glandular vestibule (*lv.*), the upper vestibule being absent. The genital retractor muscle (*rm.*) is attached to the oviduct (*ov.*) much higher up than in *A. ater* (see fig. 32).

Reproduction.—I found the eggs of the typical *A. subfuscus* commonly at Raheny, near Dublin, at the end of August, and the species also bred freely in captivity. The eggs were mostly about 3 mm. long by $2\frac{1}{2}$ mm. broad, and semi-transparent, much clearer than those of *A. ater*. Similar eggs, but rather smaller, viz. $2\frac{1}{2}$ mm. by 2 mm. were deposited in captivity by the variety shown in fig. 18. The eggs number generally about twenty in a cluster, and were seen from the middle of August to the middle of October. The young forms were not observed, and I have not sufficient data to express an opinion as to its limits of age.

Habitat.—I have taken the typical form of this species very abundantly at Raheny, Co. Dublin.* They were found in fields close to the sea where horses were kept and fungi abounded in autumn. Wherever there was any horse-manure, numbers of *A. subfuscus* were sure to be close by. But I also got them under decaying heaps of weeds in another field in the neighbourhood.

The difference between those found among the manure, and those occurring among the weeds, first drew my attention to the absence of yellow in the skin of these slugs, the colour being entirely due to the mucus. Those found among the weeds secreted hardly any of the yellow mucus, and being white with gray backs, differed at first sight very much from the vividly-coloured specimens found previously.

The first variety (fig. 18) was found in a small pine wood on Howth Hill, near Dublin, about 300 feet above the fields referred to. Similar specimens were obtained on Bray Head, in the Co. Wicklow, and, along with the variety fig. 19, at Killakee in the Dublin Mountains.

Food.—These slugs seem almost entirely to subsist on fungi, chiefly of the genus *Russula*; but they do not despise the poisonous *Agaricus muscarius*, which proves deadly to flies and other insects. I once observed two specimens eat a fallen poplar leaf in a wood, although plenty of fungi were quite close to them; but it was only after some days that specimens in captivity gnawed at the green leaves of *Campanula*. Sinroth (38) found them, especially in the north of Germany, feeding on all kinds of fungi, and observes that they never colour spirit green, which proves that they do not live on chlorophyllaceous food.

Kew (17) saw *A. subfuscus* devour a dead specimen of its own species, and also an *Amalia marginata* (= *carinata*). In captivity, he observes, they eat bread and leaves of lettuce freely, also the leaves of *Solanum dulcamara* when decomposing. A fungus (*Phallus impudicus*) was eaten voraciously, but the slugs then died, probably owing to the foetid smell given off by it.

General Distribution.—Great Britain, continental Europe (except Spain and Portugal), Iceland, and Greenland(?).

* I also found it at Glengarriff, Co. Kerry.

Arion hortensis, Férussac.

Arion hortensis, Férussac, *Hist. Moll.*, 1819. *Arion hortensis* (pars), Jeffreys, *Brit. Conch.*, 1862.

(Plate LVI., fig. 20.)

Colour of body generally dark gray or light brown, with bluish-gray sides. Lateral bands somewhat diffuse towards sides of body, always present, and continued to front of mantle. Foot always red, wrinkles broad. The calcareous grains composing shell often more aggregated than in other species. Receptaculum seminis round.

External Characters.—A typical form of this slug is at once recognized from other species by the red colour of the margin, as well as the sole, of the foot. But the intensity of this colour is subject to a good deal of variation, and in many cases the foot is more of a yellowish colour, with just a tinge of red, while sometimes only a faint indication of colouring remains. In such cases *A. hortensis* might well be mistaken for one of the other species. By a little practice, however, we can soon detect other distinguishing characters.

If we take an *A. hortensis* of 20 mm. in length, and compare it with specimens of *A. ater* (Pl. LVI., fig. 16) *A. bourguignati* (Pl. LVI., fig. 21), and *A. intermedius* (Plate LVI., fig. 22) of the same length, the little conical wrinkles will at once eliminate the latter. From *A. ater* the specimen of *A. hortensis* will be distinguished by its dark colour, young ones of the former being always light-coloured; the wrinkles, moreover, in *A. ater* are longer and broader. Sometimes *A. hortensis* is remarkably like *A. bourguignati*, but apart from the wrinkles, which are broader in the former, the lateral bands are somewhat diffuse towards the external edge, as if they had been touched by a wet brush, whilst in *A. bourguignati* their edges are well defined.

If spirit specimens of the same size are taken, which sometimes have lost all trace of colour, the wrinkles must decide, and, of course, as a last resource, the anatomy. If we measure the width of the wrinkles just behind the mantle, we find that in *A. ater* rather more than one, in *A. hortensis* two, and in *A. bourguignati* three wrinkles go to the millimetre.

So much for comparison. As for the general colour of this species, I find that two distinct varieties are as a rule found in the garden. The back of the body and mantle in the first is of a dark gray, becoming lighter towards the lateral bands. Below these the body is of a light, sometimes bluish-gray colour.

In the second variety, which was much more numerous in my garden in September, the back of body and the mantle were as if dusted over with fine yellowish

brown powder, so as to produce a light brown tint (Plate LVI., fig. 20). Below the lateral bands the body colour is a light brownish-gray.

According to Simroth (38) the light colour is produced by warmth, and the dark by cold; but whether this explanation holds good in the case of the two varieties of *A. hortensis* occurring in the same locality at the same time of year, seems to me extremely doubtful. However, I shall refer to this again in the chapter on colour.

The largest specimens of this species were 35 mm. long. The mucus is yellow and somewhat sticky.

Anatomy (Plate LVII., fig. 34).—As in the other species the characteristic part of the anatomy is to be found in the lower portion of the reproductive organ. As in *A. ater* there is an upper (*uv.*) as well as a lower vestibule (*lv.*). The free oviduct (*ov.*) is long and widened in its lower part. The sperm-duct (*sp.*) ends in a somewhat swollen "Patronenstrecke" (*pat.*), whilst the long-stalked receptaculum (*rec.*) is round. The genital retractor muscle (*rm.*) divides into two bundles, one going to the duct of the receptaculum, the other to the oviduct.

The calcareous grains under the mantle are, in this species, often aggregated so as to form a rudimentary shell, which, according to Lessona and Pollonera (21) in Italian specimens is well developed.

Reproduction.—I kept about fifty specimens in captivity from the middle of September to the end of October, but no deposition of ova took place, nor did I ever see ova that I could refer to this species. Simroth (38) had some eggs deposited by captive specimens, which were perfectly round and clear, with a diameter of 2 mm.

It is remarkable that very young specimens of this species have a keeled back, but this keel, not being different in colour from the surrounding wrinkles, is not very easily seen—and it entirely disappears in half-grown specimens.

It seems to me probable that the deposition of ova takes place in the early months of summer or spring, but additional observation is needed also with regard to the duration of life in this species. All the specimens I have seen during winter were pretty large, mostly half-grown, which leads me to suppose that no deposition of ova takes place during autumn.

Habitat.—Simroth (38) states that *A. hortensis* is a South European form, and probably does not occur north of the 52° of latitude. However, he has since examined the Irish forms, and pronounced them identical with the German ones, so that we may safely conclude that it does extend considerably farther north than Simroth anticipated.

The same author states that he has never met with a specimen anywhere but in gardens, churchyards, and within villages.

In Ireland, although also very common in gardens, it certainly has a wider

range. I have found it in a wood at Kilruddery, in Co. Wicklow; also at Killakee, in the Dublin Mountains, and other places far removed from cultivated ground.

It seemed to me remarkable never to meet with the brown, or yellowish variety in the open country—all were of a dark bluish-gray, and the foot always more yellowish than red.

Although I did not find this species in Kerry, Miss Warren kindly sent me half a dozen specimens from Sligo, and it has also been recorded by Thompson (43) from the North of Ireland.*

Food.—I had great difficulty in keeping this species in captivity, and its numbers diminished rapidly until they all died. Pieces of apple and *Campanula* leaves were eaten, but neither appeared to be relished; and I am inclined to think that *A. hortensis* lives chiefly on decaying vegetation, as they are most numerous in the garden among heaps of old weeds. I have never found it on fungi. Simroth (38) believes that it is a vegetable feeder, and that it is especially partial to heavy soil. Gain (10) also found that *A. hortensis* was rather sickly in confinement, but he states that 60 per cent. of the foods offered were taken.

General Distribution.—Great Britain and Continental Europe, except Scandinavia and Russia.

Arion bourguignati, Mabille.

Arion bourguignati, Mabille, *Rev. et Mag. de Zool.*, 1868. *Arion hortensis* (pars), Jeffreys, *Brit. Conch.*, 1862.

(Plate LVI., fig. 21.)

Colour light gray or reddish gray. Lateral bands on body continued to front of mantle. Foot always white. Wrinkles narrow. A distinct keel in young specimens. Receptaculum seminis elongate.

External Characters.—As I have pointed out above, this species is so much like *A. hortensis* that the two species are still by many conchologists mistaken for one another.

The brilliantly white foot is one of the best distinguishing characters, but by the mere touch one is often able to discriminate between the two forms, as *A. bourguignati* is always much less slimy. The wrinkles are narrower, and its whole appearance is more slender. Young specimens, as pointed out by Mabille (24), are at once recognized by the keel which, owing to its white colour is rather conspicuous. It is a somewhat smaller species than *A. hortensis*, the maximum length reaching as a rule not more than 32 mm.

* I have since found it in Wexford and Queenstown, in the South, and in Connemara, in the West of Ireland.

As in the other, there are two varieties in colour, but in the garden I have never met with the dark form. The young, both in the open country and garden, are delicately gray, with a well-defined lateral band on each side of the body and mantle. The colour remains the same in the garden forms as they grow up, but a number of reddish pigment spots appear, which produce a general effect of tan-colour. In the country specimens I have never observed this development of red pigment, and the original gray colour merely darkens, so as to produce a dark-gray slug.

Anatomy (Plate LVII., fig. 35).—Although this and the preceding species are difficult to distinguish externally, anatomically *A. bourguignati* presents unmistakable characteristics.

The hermaphrodite gland (*hg.*) is dark-brown and round. The free oviduct (*ov.*) which is long in *A. hortensis*, is here quite short, whilst on the other hand, the sperm-duct (*sp.*) is longer in *A. bourguignati*, and the "Patronenstrecke" (*pat.*) is not swollen. But perhaps the most apparent difference between the two species is the shape of the receptaculum (*rec.*) which in this species terminates in a long pointed apex. *A. bourguignati* has only one large vestibule (*lv.*), viz. the lower, whilst in *A. hortensis* there are two.

Reproduction.—I have not been able to observe the deposition of eggs in this species, although large numbers of specimens were kept in confinement during the months of September and October.

This and the almost complete absence of adults in September lead me to think that reproduction takes place early in the summer. This agrees with Simroth's (38) observations, who also found only half-grown forms during winter.

Habitat.—This species is not nearly so common as the preceding one, but still it has a wide distribution in Europe. I have obtained it commonly in my garden where the soil is heavy, and also among moss and under stones in the Dublin Mountains. In Kerry I found it on Valentia Island and at Lough Caragh, whilst Miss Warren sent me a specimen from Ballina, in Sligo.

I met with the largest specimens in June and July, but never in the daytime. This, no doubt, accounts for the fact of its having been comparatively rarely met with on the Continent, for Simroth (38) states that it is rare during summer, whilst Mabilie (24) speaks of it as "une espèce d'hiver."

Food.—Like the last, this species does not thrive in captivity, and although they will nibble at pieces of apple and rhubarb stalk, they appear to me to prefer decaying vegetation. I never found it among fungi, but in my garden, when it emerged from the ground early in the evening along with *Agriolimax agrestis*, it, as a rule, remained on the ground, whilst the latter ascended the pea plants, and did a great deal of damage by eating the young shoots and flowers. It seemed to me

as if *A. Bourguignati* preferred to feed on the fallen flowers which were partially decomposed, instead of attacking the living parts of the plant.

Gain's (10) experience is very different from mine, for he says: "This slug ate exactly one-half of the foods given, and thrives and breeds freely in confinement."

General Distribution.—Great Britain, and continental Europe, except Spain and Portugal, and Siberia (?).

Arion intermedius, Normand.

Limax intermedius, Normand, *Descr. Lim.*, 1852. *Arion hortensis* (pars), Jeffreys, *Brit. Conch.*, 1862. *Arion minimus*, Simroth, *Zeitschr. wiss. Zool.*, 1885.

(Plate LVI., figs. 22, 23.)

Colour light yellow or gray, with abundant yellow slime chiefly near head and caudal gland. Wrinkles with little conical spikes. Lateral bands either absent or very faint. It occurs chiefly on fungi.

Synonymy.—Simroth (38) was the first to re-establish on anatomical grounds the claims of this form to rank as a distinct species. Finding no satisfactory description of any species corresponding to his own, he called it *Arion minimus*, which name I temporarily adopted in a preliminary notice sent to the Conchological Society (36). Since the publication of his monograph, Simroth consulted the writings of older authors, such as Müller (28) and Nielsson (29), but as their *A. flavus* seemed to have been a larger slug, probably a young *A. subfuscus*, he thought his name (*A. minimus*) should be retained. Gmelin (11) and Férussac (8) merely repeated Müller's description without apparently having seen the slug. Among Moquin-Tandon's (26) uncertain species, we find *A. flavus* again, and there is no doubt that the author of the "Mollusques terrestres et fluviatiles de France" really had specimens of our slug before him, which he believed was the same as that referred to by Müller, Gmelin, and Férussac. But as Pollonera (32) has pointed out, the priority rests with another French author, viz. Normand (30), who described the same species under the name of *A. intermedius* three years before him.

External Characters.—This is the smallest of our Arions, and the only one besides *A. ater* which when at rest assumes the peculiar arched position (fig. 23). When examined in that attitude with a pocket lens we find that the wrinkles project in the shape of little conical knobs, and these give the slug that glittering appearance by which it is easily recognized from the other species.

The colour of *A. intermedius* is almost always white, or sometimes light gray, but owing to an abundant yellow mucus it often appears canary-yellow, especially near the caudal gland. The foot also is yellow, due to the same cause. The head and tentacles are dark gray.

The bands are sometimes completely absent, but when present, they are very faintly marked and diffuse, both on the body and mantle. I think the nature of the lateral bands and the wrinkles are the two most characteristic features in this slug.

Compared with *A. Bourguignati*, for which dark specimens might be mistaken, the touch alone will help us to some extent, *A. intermedius* being much softer, and leaving a bright yellow watery mucus behind, whilst the former is thick-skinned, with a sticky white mucus. The habitat will also distinguish the two species, as they are never found in company.

Anatomy (Plate LVII., fig. 36).—The reproductive organs, as has been shown by Simroth (38) approach those of *A. subfuscus* more than those of any other form.

The oviduct (*ov.*) is short and straight, the receptaculum seminis (*rec.*) round, and the sperm-duct (*sp.*) scarcely swollen in the "Patronenstrecke" (*pat.*). These open into a large vestibule (*lv.*).

Reproduction.—The clusters of eggs which I observed very frequently in August and September never exceeded twenty. The eggs are remarkably large for the size of the slug, being 2 mm. long by $1\frac{1}{2}$ mm. broad. The young ones of 8 mm. in length, which I bred in captivity, were of a light gray, owing to the intestine being visible through the semi-transparent walls of the body. The head was of a delicate gray, and no bands were visible on the body or mantle. Still younger ones, of 3 mm. long, were of a very light red, with violet tentacles, and had emerged from the egg three weeks after their deposition. Their limit of age has been determined by Simroth (38) as not exceeding one year. I myself found adults up to the middle of October, but not by any means so commonly as during August and September.

Habitat.—This slug is never met with in the garden or on cultivated ground. I found it for the first time last August in a field under a heap of decayed weeds at Raheny, near Dublin, in company with *Arion ater*, *A. subfuscus*, *Amalia gagates*, and *Agriolimax agrestis*. Shortly after, I obtained numerous specimens close by feeding on common mushrooms (*Agaricus*) and fungi, which had appeared in the fields.

In the Earl of Meath's demesne at Kilruddery, county Wicklow, this slug is common; also at Killakee in the Dublin Mountains. In fact, wherever there are fungi one is sure to find it, but, like *A. subfuscus*, it takes green food pretty freely in captivity. No doubt, *A. intermedius* has a wide range, but up to the present I have only taken specimens in the neighbourhood of Dublin, whilst one was sent me by the Rev. A. H. Delap, from Lough Caragh, in Kerry. This latter was of a uniformly dark gray colour.*

Food.—The nature of the food has already been referred to above. *A. inter-*

* I have since taken them in Connemara, in the West of Ireland.

medius is a most typical fungus-eating slug, and I have chiefly found them on species of *Russula*, *Agaricus*, and *Clavaria*.

General Distribution.—Great Britain, Scandinavia, Germany, France, Italy (?), and probably introduced in New Zealand.

GENUS V. *Geomalacus*, Allman, 1846.

Body sub-cylindrical; pulmonary opening on front of middle of mantle. Genital pore near base of upper tentacles. Caudal gland opening by transverse slit. There is a solid internal shell.

This genus was established by Allman (1) to include the most interesting of Irish slugs.

At first sight a *Geomalacus* looks very much like an *Arion*, but the end of the body which in that genus is pointed, and contains the longitudinal opening of the caudal gland, is, in *Geomalacus*, rounded off, so that the caudal gland opens by a transverse slit between body and foot.

The reproductive pore or genital opening lies close to the tentacles, as in the genus *Limax*, whilst in *Arion*, as we have seen, it is situated near the pulmonary aperture.

As for the anatomy, the distinctive characters of *Geomalacus maculosus* will be mentioned below, so that it remains only to be said that there is a solid internal shell, something like that in *Limax*, but very different from the calcareous particles found in *Arion*. Only one species has hitherto been found in Ireland, and it occurs nowhere else in Europe, except in North-western Spain and North Portugal. Two other species of *Geomalacus* (*G. oliveirae* and *anguiformis*) have been found in Portugal, but only short descriptions of their external characters have appeared as yet.

Mabille (23) in a Paper on the genus *Geomalacus*, described several species of French slugs, which he believed to be of this genus, but it has already been clearly demonstrated by Heynemann (13) that this view is entirely without foundation. They really belong to the genus *Arion*.

Geomalacus maculosus, Allman.

Geomalacus maculosus, Allman, *Ann. and Mag. Nat. Hist.* 1846. *Geomalacus maculosus*, Jeffreys, *Brit. Conch.* 1862.

(Plate LVI., fig. 24.)

Colour dark gray, with light yellow or whitish spots on body and mantle.

External Characters.—The figures given by Heynemann (13) in his excellent

Paper on this species, are much better than Allman's original drawings, in spite of the fact of the latter having been executed by so able a draughtsman as the late Mr. Du Noyer. Du Noyer's figures are pretty, but idealized. The only point in Heynemann's figures which I take exception to is the caudal portion of the body. This should not be so flat, but more raised as in my figure 24. Forbes and Hanley (9), Jeffreys (16), and others, seem to have merely copied Allman's figure.

This slug was discovered in the county Kerry, in the autumn of 1842, by the late William Andrews of Dublin, who placed it in the hands of Dr. Allman; and it was first exhibited at a meeting of the Dublin Natural History Society in January, 1843. The skin is always smooth and shiny, and not black, but of a dark gray colour.

Both on the mantle and back there are a series of yellowish-white or yellow spots. These seem at first sight quite irregularly placed on the body, but Simroth (39) has drawn attention to the fact that on closer inspection there appear traces of distinct longitudinal bands, as in *Arion*. In most cases, indeed, I have observed these very well, but in others the banding is very difficult to demonstrate. The margin as well as the sole of the foot are of a dirty white. The tips of the tentacles are cylindrical, whilst in the genus *Arion* they are round. The mucus is transparent and limpid. The largest specimen measured about 55 mm. in length.

Mabille (23), in his Paper on the genus *Geomalacus*, referred to on p. 551, has attempted to set up a second species, which he calls *G. andrewsi*. His assumption is based on Allman's original description, who mentions, besides the common form, a white-spotted variety. Mabille believed that this meant a white, spotted variety, *i.e.* a white slug with black spots, and, astounding as it may appear, proceeded on these grounds to describe it as a new species.

Anatomy (Plate LVII., fig. 37).—Heynemann (13) does not deal with the anatomy of this slug, excepting in a reference to the shell and the tongue, neither of which is of very great importance. The latter is very much like that of an ordinary *Arion*, but the shell is firm and regular like that of a *Limax*.

The fact that the calcareous particles often congregate together in *Arion intermedius*, and form a kind of irregular shell, has induced French authors, such as Mabille (23) and Baudon (2), to start the idea that this slug must be a *Geomalacus*; but the shell in the genuine *Geomalacus* is of a very different nature. The intestine resembles that of *Arion*, but the reproductive organs differ widely.

The penis (*p*) is formed by the enormously developed duct of the receptaculum seminis (*rec.*), and not by the oviduct, as in *Arion*. There is a long retractor muscle (*rm.*) attached to the penis at the part where the sperm-duct opens into it. The sperm-duct (*sp.*) is very much longer than in any *Arion*, whilst the ovisperm-duct (*os.*) is shorter.

Reproduction.—I found a few half-grown specimens along with the adults last May, but did not observe the eggs. Dr. Simroth very kindly sent me the proof-sheet of his large Memoir on the Slugs of Portugal and the Azores (40), and in it I find a statement that a Signor de Silva e Castro had seen the eggs. They were quite transparent, and very large, measuring from 5 to 7 mm. long, and 3 mm. broad. Simroth obtained about 40 young ones at Las Caldas de Gerez, in Portugal.

Habitat.—The first living specimens I have seen were presented to me last April by Mr. A. G. More. They had been collected on the eastern shores of Lough Caragh, in county Kerry, the same locality where Andrews had originally discovered the slug.

In the following May, while returning home from the dredging expedition to the West Coast, organized by the Royal Dublin Society, I passed Lough Caragh, and spent a portion of the night in hunting for this interesting slug, but without success. The following morning I walked to the eastern shores of the lake, and although I turned over hundreds of stones, I discovered nothing but *Limax maximus*, *L. marginatus*, and *Arion ater*. I was about to give up the search, when I noticed a young specimen concealed among the lichens which grow here so abundantly on the surface of the rocks, and, after a while, I found several others similarly exposed to the full rays of the sun, it being then about two o'clock in the afternoon.

The dark gray lichens, with the white or yellowish fructification, conceal the slug perfectly, and there is no doubt that we have here a most striking instance of protective colouring. Lough Caragh is situated close to the head of Dingle Bay, in County Kerry, and, up to quite recently, it was the only spot in Ireland where this slug had been found, but, during last autumn, Mr. Scully discovered it about twenty-five miles further south, on the Kenmare and Glengariff road.*

I notice in Simroth's (40) proof, referred to above, that he found this species among lichens at the foot of a granite wall in the province of Minho, in Northern Portugal. A single specimen was collected in 1868, according to Heynemann (13), by Lucas Von Heyden, in the province of Asturias, in Northern Spain. Two other species, *G. oliveiræ* and *G. anguiformis*, from Central and Southern Portugal, will be described in Simroth's forthcoming Memoir (40).]

Food.—*G. maculosus* undoubtedly lives on lichens, as I have been able to demonstrate by microscopic examination of the contents of the intestine.

In captivity it readily takes to other food, and thrives on dandelion leaves; and Heynemann (13) succeeded in keeping Irish specimens during a whole winter on lettuce, gherkins, &c.

General Distribution.†—Northern Portugal, and N. W. Spain.

* In May, 1891, I found this species abundantly still further South at Glengariff, county Cork.

† The question of the peculiar geographical distribution of this slug will be dealt with in a special Memoir, which I hope to publish during the course of this year.

The Colours of Slugs.

A good deal has been written in various Zoological works on the colours of animals in general, and Poulton has recently published a most interesting work, chiefly on the colours of Insects. He finds that a variety of causes influence the production of colours, but that by far their most widespread use is to assist an animal in escaping from enemies or in capturing its prey.

The view that colour is of direct physiological value to slugs has been ably argued by Simroth in the cases of *Arion ater* and *Limax maximus*, and Eimer (6) seems to support Leydig's view, that the darker colour of *A. ater* on the sea-coast may be caused by the greater moisture of the atmosphere. However, I hope I shall be able to show that neither of these views are altogether borne out by facts. Cockerell (4), judging from some specimens sent to him from a mountain in county Waterford, draws the conclusion that altitude influences the colour of slugs, but this also, I believe, is not supported by sufficient evidence.

I think that the colours of slugs in Ireland are at all ages, as a rule, protective. Simroth (38) agrees with this as far as the smaller species are concerned, but he excepts *Limax maximus* and *Arion empiricorum* (= *ater*), because they are often distinguished by strikingly vivid colours.

He made numerous experiments with the latter species, kept it in a hot atmosphere, and offered it to various birds as food, and finally came to the conclusion that the colour in the brick-red variety is a warning colour. The object of a so-called warning colour, I may say, is to render the animal as conspicuous as possible, in order to enable its enemies to easily learn and remember the animals which are to be avoided on account of any noxious properties they may possess.

Simroth (38), moreover, points out that all the very variable species of slugs, such as *Arion ater* and *Limax maximus*, are darkly coloured both at their southern and northern limits of range, the shores of the Mediterranean, and Scandinavia. He supposes this to be due to a natural protection against heat and cold, *i.e.* he believes that colour is of direct physiological value.

We know, however, that dark colours absorb radiant heat easily, while light colours do so with difficulty; and it seems therefore surprising that Simroth (38) did not take into account the fact that the white variety of *A. ater* in Scandinavia is almost as common as the black [Esmark (7)]. Both on the Continent and in Ireland the young of *A. ater* are brilliantly coloured during winter, and most specimens darken at the approach of summer.

If Simroth's theory were correct, one would expect the slugs which are destined to resist the severe cold of a Continental winter to be coloured dark. All young specimens, however, whether they produce black or brown adults, are light-coloured

in their youth, and the colour of the adults varies between black, brown, and red in Germany, just as it does in Ireland, with the exception that the brick-red form so common in Germany is absent with us.

Simroth's experiment of offering *A. ater* as food to various birds, and its being refused by them, does not seem to me conclusive, as birds kept in captivity get a regular diet, and become in time rather dainty feeders. Besides, large birds such as gulls, are decidedly rare in Germany, and I think it much more likely that toads or some of the insectivorous mammals do a great deal of damage among slugs; and it is possibly these that have a particular aversion to the bright red slugs, owing to their more acrid slime. Their colour is certainly most conspicuous, and on a rainy day they are often seen in hundreds in broad daylight in the forests of Germany.

I do not believe their colour is influenced by the temperature, for we find black and brown forms of the same species living in such a dry climate as that of Eastern Germany and on the very humid West Coast of Ireland—in cold and bleak Norway as well as on the parched plains of Spain and Portugal.

In this country, as I mentioned before, I have met with the uniformly black, the brown, olive, claret, and light red varieties of *A. ater*, and one variety which is black above, with yellow sides. The olive and light red forms occur only on the West Coast, but the black and brown ones are equally common there. In boggy ground most of those I saw were either olive or a rich burnt sienna brown. Their colour harmonizes most perfectly with the brown of the turf and the olive-coloured moss growing on it. I have also observed the light red in that neighbourhood, but no natural object seemed to me to exactly resemble it.

Perhaps the wettest spot on the West Coast is the Skellig Rock, an immense rock, entirely bare, over the greater part of which the huge Atlantic waves break, scattering their spray completely over the highest parts. From this rock I have the olive and black variety of *A. ater*. If moisture caused darkness, they would all be black there, for a more humid place can scarcely be imagined.

Certainly, I have everywhere met with black specimens very close to the sea, both on the West and especially on the East Coast, and that fact taken alone might lead us to suppose that moisture had something to do with the darkness of their colour; but black specimens are equally common inland a long way from the sea, whilst on cultivated ground, even if it should be quite close to the shore, we find almost invariably the brown variety.

Another remarkable circumstance is that along the sea-shore near Dublin one meets very frequently with the black and yellow variety, *i.e.* black with yellow sides (Plate LVI., fig. 15.) A variety with white sides has been recorded from the coast of Wales, and Simroth obtained them also from the shores of the German Ocean.

It seems clear that the sea has some connexion with this variety at any rate, but I think its connexion is only of an indirect nature. It struck me at first that the sides of the slugs might be more stimulated to secrete mucus than the back, as the animals would have to crawl over grass which must be coated with depositions of salt; but why should they not then all be of that variety near the sea? Entirely black ones are, in fact, rather more common.

There is another more likely explanation to account for the fact of the bicoloured dress of the young being retained in the adult on the sea-shore. It appeared to me that in the twilight of morning and evening the black-and-yellow forms might have equal advantages of concealment with the black ones, when crawling among the stones at the sea-shore, for I believe this species is just as much preyed upon as other slugs by the innumerable birds frequenting Dublin Bay. It is well known that the gizzard of gulls is frequently found to be filled with slugs of all kinds, whilst Thompson (43) often found the shell of *Limax maximus* and *Agriolimax* in the stomach of the thrush.

The only place where I have found the claret-coloured variety was in pine woods at Killakee and Howth, where the general colouring of the ground resembles that of the slug, and at once suggested to me the protective character of its colour. As regards the young winter forms of *Arion ater*, I have always noticed that they choose the yellow fallen leaves, whose colour they resemble very closely, for hiding-places, and here again it is the need of protection and not temperature which influences their colouring.

As for the other species of slugs, we have very good examples of protective colouring in *Limax marginatus*, *Amalia carinata*, *Arion intermedius*, and *Geomalacus maculosus*. The first, when on a tree-trunk, which is its favourite haunt, is easily mistaken for a piece of bark; the second resembles the ground in which it spends almost its entire existence; the third looks very like a little fungus just coming out of the ground, while the last imitates the colour of the lichen among which it lives to a remarkable degree.

In the other slugs protective colouring is perhaps not quite so apparent, but I have no doubt that in all cases their colour is mainly influenced by the natural selection of those best suited to escape the keen sight of their enemies.

PAPERS AND WORKS REFERRED TO.

- 1 ALLMAN, G. J., . "Description of a new Genus of pulmonary Gastropod."—Ann. & Mag. Nat. Hist., vol. 17, 1846.
- 2 BAUDON, AUG., . "Mémoire sur les Limaciens du Département de l'Oise."—1871.
- 3 CLARKE, B. J., . "On the species of *Limax* found in Ireland."—Ann. & Mag. Nat. Hist., vol. 12, 1843.
- 4 COCKERELL, T. D. A., "*Limax arborum* and the influence of altitude on colour."—Zoologist, vol. 10, 3rd ser., 1886.
- 5 DRAPARNAUD, J., . "Hist. nat. des Moll. terr. & fluv. de France."—1805-31.
- 6 EIMER, G. H. T., . "Organic Evolution."—(Translated by J. T. Cunningham), 1890.
- 7 ESMARK, BIRGITHE, . "Land and Freshwater Mollusca of Norway."—Journal of Conchology, vol. 5, 1886-88.
- 8 FÉRUSSAC, A. E., . "Histoire nat. des Mollusques."—1819.
- 9 FORBES AND HANLEY, "History of British Mollusca."—4 vols, 1853.
- 10 GAIN, W. A., . "A few notes on the Foods and Habits of Slugs and Snails."—Naturalist, 1889.
- 11 GMELIN, J. F., . "Systema nat."—1788-90, xiii ed.
- 12 HANTSCH, R., . "Contributions to the Anatomy and Histology of *Limax agrestis*—Proceed. Soc. Liverp., vol 2, 1888.
- 13 HEYNEMANN, D. F., . "Über *Geomalacus*."—Malakozool. Blätter, vol. 21, 1873.
- 14 do. "*Limax brunneus*, Drp."—Malakozool. Blätter, vol. 19, 1872.
- 15 do. "Über *Limax variegatus*, Drp."—Malakozool. Blätter, vol 7, 1861.
- 16 JEFFREYS, J. G., . "British Conchology."—vol. 1, 1862.
- 17 KEW, H. W., . "Notes made in 1888 upon *Arion ater* and some other Slugs."—Naturalist, 1889.
- 18 LAWSON, H., . "General Anatomy of *Limax maximus*."—Microsc. Journal, vol. 3, n. s., 1863.
- 19 LEACH, W. E., . "Synopsis of the Mollusca of Great Britain " (Proofs published in 1820).
- 20 LEHMANN, R., . "Die lebenden Schnecken und Muscheln in Pommern."—1873.
- 21 LESSONA UND POLLONERA, "Monographia d. Limacidi italiani."—1882.
- 22 LISTER, M., . "Synopsis Conchyliorum, &c."—1685.
- 23 MABILLE, M. J., . "Le Genre *Geomalacus* en France."—Revue et Mag. de. Zoologie, vol. 19, ii. ser., 1867.
- 24 do. "Les Limaciens européens."—Revue et Mag. de Zoologie, vol. 20, ii. ser. 1868.

- 25 MALM, A. W., . "Skandinaviska Land Sniglar."—1870.
- 26 MOQUIN-TANDON, A., "Hist. nat. d. Moll. terr. et fluv. de France."—1855.
- 27 MORELET, A., . "Deser. d. Moll. terr. et fluv. du Portugal."—1845.
- 28 MÜLLER, O. F., . "Vermium terrest. et fluv. historia."—1774.
- 29 NIELSSON, S., . "Hist. Moll. Sueciae terr. et fluv."—1822.
- 30 NORMAND, N. A. J., "Deser. de six Limaces nouvelles."—1852.
- 31 NUNNELEY, Th., . "Deser. of the Limaces found in the neighbourhood of Leeds."—Trans. Leeds Phil. and Lit. Society, 1897.
- 32 POLLONERA, C., . "Specie nuove o mal conosciute di Arion europei."—Atti d. R. Acad. di Torino, vol. 22, 1886-87.
- 33 do. "Nuove contribuzioni allo studio degli Arion europei."—Atti. d. R. Acad. di Torino, vol. 24, 1889.
- 34 REEVE, L., . "Land and Freshwater Mollusca of the British Isles."—1863.
- 35 ROEBUCK, W. D., . Numerous Notes and Papers.—Journal of Conchology, vols. 4-6, 1883-1890.
- 36 SCHARFF, R. F., . "*Arion minimus* (Simroth) a British Slug."—Journal of Conchology, vol. 6, 1890.
- 37 SCOTT, R. H., . "The Variability of the Temperature in the British Isles."—Proc. Roy. Soc., vol. 47, 1890.
- 38 SIMROTH, H., . "Naturgesch. d. deutsch. Naektschnecken."—Zeitschr. f. wiss. Zoologie, vol. 42, 1885.
- 39 do. "Über bekannte und neue palaearkt. Naektschnecken."—Jahrb. d. deutsch. Malakoz. Gesellsch., vol. 13, 1886.
- 40 do. "Die Naektschnecken d. portugies-azorisch Fauna."—Nova Acta Acad. C. L. C. G. Nat. Cur., vol. 56, 1891 (Proof).
- 41 TAYLOR, J. W., . Numerous Papers and Notes.—See Journal of Conchology, vols. 1-6.
- 42 TAYLOR AND ROEBUCK, "Materials towards a Land and Freshwater Moll. Fauna of Ireland."—Proceed. R. I. Acad., ser. 2, vol. 4, 1888.
- 43 THOMPSON, W., . "Natural History of Ireland," vol. 4, 1856.
- 44 WESTERLUND, C. A., "Fauna Europea Moll. extra marinorum," 1877-78.

EXPLANATION OF PLATE LVI.

EXPLANATION OF PLATE LVI.

Fig.

1. *Limax maximus*, L., dark variety (rather more than half-grown), from Raheny, Co. Dublin.
2. " " (not quite half-grown), from Leeson Park, Dublin.
3. " *flavus*, L. (full-grown), from Raheny, Co. Dublin.
4. " *marginatus*, Müller (full-grown), from Killakee, Co. Dublin.
5. *Agriolimax agrestis*, L. (full-grown), from Leeson Park, Dublin.
6. " " L., variety (full-grown) from Rathfarnham, Co. Dublin.
7. " *lucris*, Müller (twice natural size, almost full-grown), from Killakee, Co. Dublin.
8. *Amalia carinata*, Leach (full-grown), from Leeson Park, Dublin.
9. " *gagates*, Drap. (full-grown), from Raheny, Co. Dublin.
10. *Arion ater*, L., brown variety (full-grown), from Leeson Park, Dublin.
11. " " variety (half-grown), resting position, from Raheny, Co. Dublin.
12. " " variety (half-grown), not fully extended, from Howth, Co. Dublin (Redding).
13. " " variety (young), from Killakee, Co. Dublin.
14. " " brown variety (young of fig. 10), from Leeson Park, Dublin.
15. " " variety (half-grown), from Howth, Co. Dublin (Redding).
16. " " variety (half-grown), from Rathfarnham, Co. Dublin.
17. " *subfuscus*, Drap. (full-grown), from Raheny, Co. Dublin.
18. " " variety (full-grown), from Howth, Co. Dublin.
19. " " variety (full-grown, sexually undeveloped), Killakee, Co. Dublin.
20. " *hortensis*, Fér., brown variety ($1\frac{1}{2}$ times natural size, full-grown), Leeson Park, Dublin.
21. " *bourguignati*, Mabilie, brown variety ($1\frac{1}{2}$ times natural size, full-grown), Leeson Park, Dublin.
22. " *intermedius*, Normand (full-grown), from Raheny, Co. Dublin.
23. " " " variety (full-grown), resting position, from Killakee, Co. Dublin.
24. *Geomalacus maculosus*, Allman (full-grown), from Shore of Lough Caragh, Co. Kerry.

EXPLANATION OF PLATE LVII.

LETTERING ADOPTED IN ALL THE FIGURES.

<i>hg.</i> . . .	hermaphrodite gland.	<i>p.</i> . . .	penis.
<i>hd.</i> . . .	hermaphrodite duct.	<i>rm.</i> . . .	genital retractor muscle.
<i>ag.</i> . . .	albuminiparous gland.	<i>fl.</i> . . .	flagellum.
<i>os.</i> . . .	ovisperm-duct.	<i>pat.</i> . . .	portion of sperm-duct in which spermatophore is formed (Patronenstrecke).
<i>ov.</i> . . .	oviduct.	<i>uv.</i> . . .	upper vestibule.
<i>sp.</i> . . .	sperm-duct.	<i>lv.</i> . . .	lower vestibule.
<i>rec.</i> . . .	receptaculum seminis.	<i>ac.</i> . . .	accessory gland.

EXPLANATION OF PLATE LVII.

Fig.

25. *Limax maximus*, L. (reproductive organs), very dark form, from Killakee, Co. Dublin, October, 1890.
26. „ *flavus*, L. (reproductive organs), from Raheny, Co. Dublin, October, 1890.
27. „ *marginatus*, Müller (reproductive organs), from Co. Wexford, August, 1890.
28. *Agriolimax agrestis*, L. (reproductive organs), magnified, from Aran Islands, October, 1890.
29. „ *laevis*, Müller (reproductive organs), magnified, from Killakee, Co. Dublin, September, 1890.
30. *Amalia carinata*, Leach (reproductive organs), magnified, from Aran Islands, October, 1890.
31. „ *gagates*, Drap. (reproductive organs), from Raheny, Co. Dublin, September, 1890.
32. *Arion ater*, L. (reproductive organs), black variety, from Raheny, Co. Dublin, August, 1890.
33. „ *sulfuscus*, Drap. (reproductive organs), magnified, from Raheny, Co. Dublin, September, 1890.
34. „ *hortensis*, Fér. (reproductive organs), magnified, from Leeson Park, Dublin, October, 1890.
35. „ *bourguignati*, Mabilie (reproductive organs), magnified, from Leeson Park, Dublin, July, 1890.
36. „ *intermedius*, Normand (reproductive organs), magnified, from Raheny, Co. Dublin, September, 1890.
37. *Geomalacus maculosus*, Allman (reproductive organs), from Co. Kerry, May, 1890.

Limax maximus

Limax flavus

Limax marginatus

Limax agrestis

Agriolimax laevis

Amalia carinata

Amalia gagates

Arion ater

Arion subfuscus

Arion hortensis

Arion boissagii

Arion intermedius

Limaculus maculosus

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