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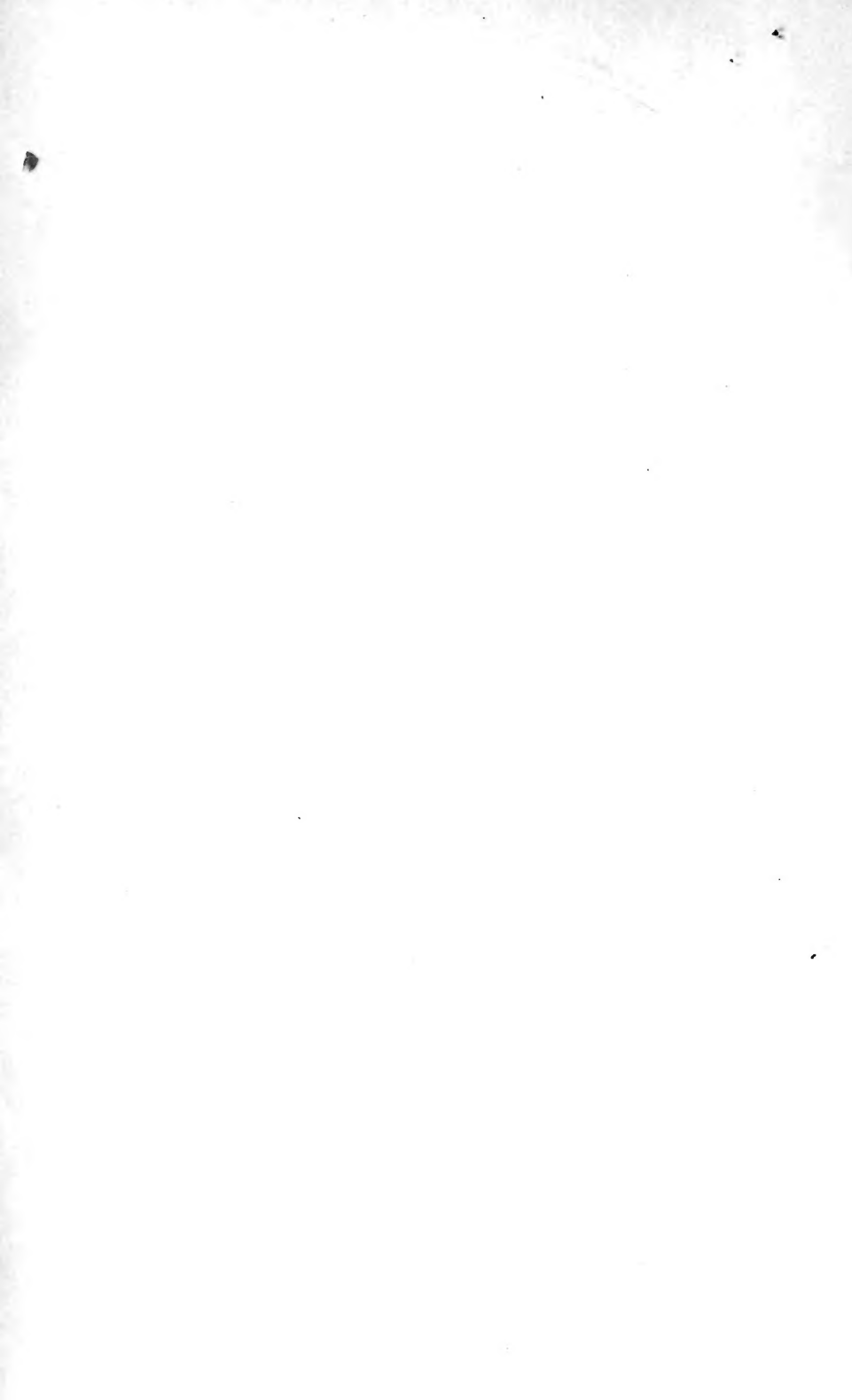


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The
Amphipoda of Bermuda

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I.—THE AMPHIPODA OF BERMUDA.

By B. W. KUNKEL, PH.D.

The Amphipoda of the Bermudas and West Indies apparently have been almost entirely neglected by systematists. The only notices which we have of Amphipoda from Bermuda are those of *Caprella danilevskii* (Czerniavski, 1868), recorded by Stebbing in the "Challenger" Report (vol. 39, p. 1364, pl. 145), *Cyamus fascicularis* (Verrill, 1903) from a sperm whale captured off Bermuda and exhibited at St. George's, and *Orchestia agilis* (Smith, 1873) which Verrill notes as being abundant (Trans. Conn. Acad., vol. XI, p. 21-22, 1903).

The greater part of the material for the present study was collected by Prof. Verrill and parties during two expeditions to the islands in the spring of 1898 and 1901, and was turned over to the writer for study in the spring of 1906; besides this material, several vials bore the label of G. Brown Goode, 1876-77, several that of W. M. Rankin, 1898, and one vial was received from Dr. L. J. Cole, dated Bermuda Biological Station, July 15, 1903.

In general, no exact data regarding the localities and surrounding conditions were recorded, but where such are known due reference will be made to them. The collecting by Verrill was done in shallow water along the shore, at most in only a few fathoms, and nearly all the forms are shallow water species.

The most striking peculiarity of the Amphipodous fauna of Bermuda is its close relationship to that of the Mediterranean. Of the 45 species recorded from Bermuda, 19, or possibly 20, of them occur also in the Mediterranean, and nearly all of these are abundant in European waters. Eighteen of these 45 species are peculiar to Bermuda and only 7 species which are not endemic, are not found also in the Mediterranean. Thus nearly $\frac{1}{2}$, or 44%, of the known species of Bermuda Amphipoda are Mediterranean. In contrast to the richness of European forms the 9 species common to South and Central American shores is striking, especially in view of the fact that 93% of the Decapod Crustacea of Bermuda have been recorded from the Florida Keys and the West Indies (Verrill, Trans. Conn. Acad., vol. XIII, p. 452, 1908). This paucity of forms from Central and South America probably has little significance, however,

and is due simply to the small amount of collecting of the smaller Crustacea from these waters.

The distribution of the species of Amphipoda known to occur in the waters of Bermuda is designated in the following list. New species are printed in heavy-faced type and new genera are preceded by an asterisk.

1. *Lysianassa punctata*. Naples.
2. *Amphilocheus brunneus*. Naples.
3. *Leucothoe spinicarpa*. Arctic Ocean, North Atlantic, North Sea and Skagerrak, Greenland; Norway, British Isles, Azores, France, Mediterranean.
4. *Stenothoe marina*. North Atlantic, North Sea, Adriatic Sea.
5. *S. valida*. Rio Janeiro, Mediterranean?
6. ***Pariphinotus tuckeri**.
7. *Colomastix pusilla*. British Isles, France, Mediterranean.
8. **Panoploeopsis porta**.
9. *Eusiroides crassi*. South Atlantic.
10. **Pontogeneia verrilli**.
11. *Melita fresnelii*. Rio Janeiro, Singapore, Port Jackson, N. S. Wales.
12. **M. planaterga**.
13. *Ceradocus orchestiipes*. Mediterranean.
14. **C. parkeri**.
15. **C. colei**.
16. *Maera inaequipis*. Mediterranean, Azores.
17. *M. rathbunae*. Key West, Fla.
18. **M. tinkerensis**.
19. *Elasmopus rapax*. British Isles, Christianiafjord, France, Azores, Mediterranean.
20. **E. magnispinatus**.
21. *E. pocillimanus*. Mediterranean, Atlantic coast of North America (Long Island Sound, Vineyard Sound).
22. **Gammarus breweri**.
23. ***Insula antennulella**.
24. *Orchestia platensis*. Rio de la Plata, Atlantic coast of North America (Bay of Fundy to New Jersey), Mediterranean, Sea of Tiberias.
25. *Hyale prevostii*. Mediterranean. Atlantic Coast of North America, Rio Janeiro, Valparaiso, Peru.
26. *H. pontica*. North Atlantic, North Sea, Mediterranean.
27. **H. trifoliadens**.
28. ***Parhyalella batesoni**.

29. *Microdeutopus anomalus*. Atlantic coast of Norway, Shetland Isles, Black Sea.
30. *Autonoe longipes*. Naples, Scandinavia, British Isles, Port Jackson, N. S. Wales.
31. **Eurystheus lina.**
32. *Podoceropsis sophia*. Arctic Ocean, Scandinavia, British Isles, Shetland.
33. **Isaea longipalpus.**
34. *Amphithoe longimana*. New England coast.
35. *A. rubricata*. North Atlantic and adjoining seas of Europe.
36. **A. pollex.**
37. *Grubia crassicornis*. Naples, Black Sea.
38. **G. coei.**
39. *Erichthonius braziliensis*. Atlantic coast of North America, Norway, Adriatic Sea, Rio Janeiro, San Francisco, Cal.
40. *Chelura terebrans*. Atlantic coast of North America, Norway to Black Sea.
41. *Caprella equilibra*. Mediterranean, Norway, Charleston, N. Car., Rio Janeiro, Hong Kong, N. S. Wales.
42. **C. bermudia.**
43. *C. danilevskii*. Mediterranean, Black Sea, Copenhagen, Bay of Biscay, Sea of Japan, Port Jackson, N. S. Wales, Rio Janeiro.
44. *Protellopsis stebbingii*. Gulf of Mexico.
45. *Cyamus fascicularis*.

The specimens were all of relatively small size, the largest specimen measuring less than 20 mm. in length, which is in accord with previous observations that the Amphipoda of Arctic regions are of larger size than those of warm waters.

The classification of the Gammaridea into families is in a rather unsatisfactory condition and no attempt at revision has been made in the following pages. Boeck (1876) divides them into 10 families and 22 subfamilies; Stebbing (1888) in the "Challenger" Report makes 26 families and in his later work on the Gammaridea (1906) he recognizes 41 families; Della Valle (1893) in his monograph recognizes only 10 families which, however, differ from Boeck's; and Sars (1895) divides the Gammaridea of Norway alone into 26 families.

For complete synonymy, reference should be made to the extensive works of Stebbing, Sars, and Della Valle. Acknowledgment is made at this time of the privileges of the laboratory of the U. S. Bureau of Fisheries at Woods Hole, Mass. where part of this work was done in the summer of 1906.

Tribe GAMMARIDEA.

Head rather small, not fused with first thoracic segment; eyes rarely of very large size, usually compound, first antennae consisting of 3-jointed peduncle and flagellum; second antennae with peduncle usually consisting of 5 joints and flagellum; maxillipeds with inner plates free and with 2- to 4-jointed palps.

Body usually compressed; thorax of 7 distinct segments, rarely reduced to 6; 5 or 6 segments bearing gills; 4 segments in female bearing marsupial plates; thoracic legs overlapped at base by epimera, the first 4 being usually larger than the posterior 3.

First 3 abdominal segments always free; posterior 3 usually distinct; uropod 1 always biramous.

Key to the genera of the Gammaridea.

- | | | | |
|---|---|--|----------------------|
| 1 | { | Gnathopod 2 with third joint elongate | Lysianassa |
| | | Gnathopod 2 with third joint short 2 | |
| 2 | { | Gnathopod 2 with fifth joint greatly prolonged;
telson elongate, tapering, entire | Amphilochus |
| | | Not with same combination of characters . . . 3 | |
| 3 | { | Gnathopod 1 with chela formed by fifth and sixth
joints | Leucothoe |
| | | Gnathopod 1 otherwise 4 | |
| 4 | { | Epimeron 4 enormously developed | Stenothoe |
| | | Epimeron 4 not especially large 6 | |
| 5 | { | Gnathopods 1 and 2 simple; body depressed and
ridged dorsally; pleopod 3 with peduncle ex-
panded to form long process | Pariphinotus |
| | | Not with same combination of characters . . . 6 | |
| 6 | { | Gnathopod 2 with second joint rather slender and
greatly enlarged distally, gnathopod 1 very
small | Colomastix |
| | | Gnathopods otherwise 7 | |
| 7 | { | Epimera 1-3 tapering acutely ventrally | Panoploeopsis |
| | | Epimera 1-3 more or less rounded ventrally . 8 | |
| 8 | { | Antennae with calceoli 9 | |
| | | Antennae without calceoli 10 | |

9	}	Antenna 1 with accessory flagellum	Eusiroides
		Antenna 1 without accessory flagellum	Pontogeneia
10	}	Antenna 1 with accessory flagellum of more than 2 joints; pereopods 1 and 2 without glands; uropod 3 projecting beyond others, biramous; telson cleft	11
		Not with same combination of characters	15
11	}	Uropod 3 with rami very unequal	Melita
		Uropod 3 with rami not very unequal	12
12	}	Maxillae 1 and 2 with outer and inner plates very setose	13
		Maxillae 1 and 2 with outer and inner plates not very setose	14
13	}	Pleon segments 4-6 with dorsal spinules	Gammarus
		Pleon segments 4-6 without dorsal spinules	Ceradocus
14	}	Pereopods 3-5 slender	Maera
		Pereopods 3-5 robust	Elasmopus
15	}	Antenna 1 with no accessory flagellum; mandible without palp; pereopods 1 and 2 without spinning glands; uropod 3 small, uniramous	16
		Not with this combination of characters	19
16	}	Maxilliped with 3-jointed palp	Insula
		Maxilliped with 4-jointed palp	17
17	}	Antenna 1 shorter than peduncle of 2	Orchestia
		Antenna 1 longer than peduncle of 2	18
18	}	Maxilla 1 with palp	Hyale
		Maxilla 1 without palp	Parhyalella
19	}	Antenna 1 with accessory flagellum well developed; maxilla 1 with inner plate small; pereopods 1 and 2 with spinning glands; gnathopod 1 larger than gnathopod 2	20
		Not with this combination of characters	21
20	}	Gnathopod 1 in male with fifth joint produced to form a large tooth	Microdeutopus
		Gnathopod 1 in male with fifth joint not so produced	Autonoe
21	}	Antenna 1 with accessory flagellum; lower lip with anterior margin of outer plate entire; pereopods 1 and 2 with spinning glands; uro- pod 3 not uncinata	22
		Not with this combination of characters	24
22	}	Telson emarginate	Eurystheus
		Telson entire	23

23	{	Pereiopods 1-5 not subchelate	Podoceroopsis
		Pereiopods 1-5 subchelate	Isaea
24	{	Lower lip with anterior margin of outer plate incised; pereiopods 1 and 2 with spinning glands; uropod 3 uncinata	25
		Not with these characters	26
25	{	Antenna 1 without accessory flagellum	Amphithoe
		Antenna 1 with accessory flagellum	Grubia
26	{	Antenna 1 without accessory flagellum; antenna 2 with flagellum not spatulate	Erichthonius
		Antenna 1 with accessory flagellum: antenna 2 with spatulate flagellum	Chelura

Lysianassa punctata (O. G. Costa, 1840), Stebbing, 1906.

1840. *Callisoma punctata*. O. G. Costa, Fauna Reg. Napoli, Crost., Cat. p. 5.

1906. *Lysianassa punctata*. Stebbing, Das Tierreich, Lief. 21, p. 40.

Eyes large, compound, reniform, ocelli large and not crowded together, pigmented in specimens preserved in alcohol.

First antennae very short; first joint of peduncle twice as long as second, third joint shorter than second; principal flagellum made up of about 10 joints, about as long as peduncle; accessory flagellum composed of 4 joints, about half as long as principal flagellum. Second antennae shorter than first and more slender; flagellum shorter than peduncle, made up of 5 joints; fourth and fifth joints of peduncle subequal; third joint shorter than fourth.

Mandibles with body rather slender; cutting edge not denticulated; palp long, 3-jointed, third joint slender and not quite as long as second, provided with several spinules apically; molar tubercle wanting. Lower lip with inner plates small and rounded; outer plates triangular, much longer than broad. First maxillae with inner plates very small: outer plates with branched spines on distal margin; palp made up of 2 joints, of which the first is very short and the second has a serrated, blunt distal end. Second maxillae with inner plate much broader than outer and of about same length, broader at distal end which is oblique and provided with spinules. Maxillipeds with 3-jointed palp having terminal dactyl-like spine; second joint rather long and slender, with slender spinules on inner margin; third joint with long spinules apically: inner plates with 3 teeth on round distal margin, fine cilia on inner margin; outer plates moder-

ately broad, unarmed, extending nearly as far as second joint of palp.

In female, first gnathopods with triangular epimeron, with anterior ventral angle rounded; second joint fairly stout, cylindrical; third joint broader than long; fourth triangular with posterior margin convex and provided with setae toward apex; wrist somewhat longer than broad and provided with setae apically; hand slender and

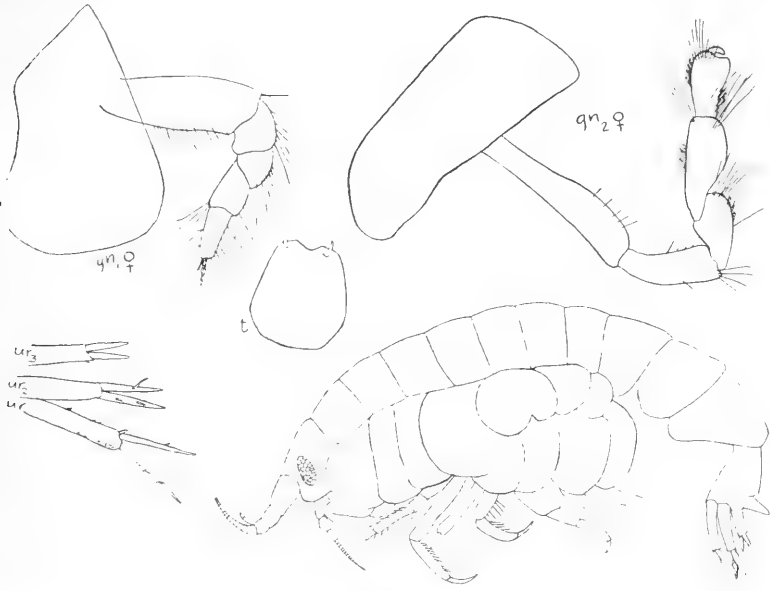


Fig. 1. *Lysianassa punctata* (O. G. Costa).

tapering; not subchelate, posterior margin provided with long setae and sharp tooth-like spines; finger short and curved, unguiform.

Second gnathopods with narrow epimeron more than twice as high as long, rhomboidal; second joint long and very slender, slightly broader distally than proximally; third joint 4 times as long as broad; fourth joint about $\frac{1}{2}$ as long as third, broader at distal end than at proximal, rounded apically, articulating with wrist by distal half of anterior margin; wrist longer than third joint, triangular, broadest at middle, posterior margin convex, anterior margin straight with many fine setae near middle; hand shorter and narrower than wrist, subrectangular, broader at distal margin which is transverse and concave, anterior margin with abundant fine setae toward apical portion, distal portion of posterior margin with many closely set

sharp teeth; finger very short and curved, not as long as width of distal end of hand.

Pereiopods of usual form without spinning glands; epimera rather high, third epimeron rectangular; fourth greatly elongated at inferior margin forming a posterior projection above which the anterior margin of fifth epimeron fits; fifth epimeron with inferior margin incised by deep split.

Postero-inferior margin of third abdominal segment rounded, entire.

Uropods, 3 pairs, biramous; rami subequal, styloform and slender; first pair projecting beyond second; second projecting beyond terminal; in first and second pairs rami and peduncle subequal; terminal uropods short, with rami shorter than peduncle.

Telson small, longer than broad, bearing apically a slight depression medially and a short toothlike spine on each side.

There were only 2 females in the collection.

The species has been recorded previously only from Naples.

Amphilochus brunneus Della Valle, 1893.

1893. Della Valle, Fauna und Flora des Golfes von Neapel, vol. 20, p. 596; pl. 4, fig. 5 and pl. 29, fig. 1-15.

Eyes circular, compound, made up of many ocelli closely packed together.



Fig. 2. *Amphilochus brunneus* Della Valle.

First antennae short, first and second joints of peduncle each about as broad as long and about $\frac{2}{3}$ as long as third which is about twice as long as wide; flagellum short and thick, composed of 8 or 9 segments, each of which is provided with a long and a short spine at distal margin. Second antennae slightly longer than first with moderately slender gland cone; fourth and fifth joints of equal length, but fourth much thicker than fifth; flagellum short and thick, about $\frac{2}{3}$ as long as peduncle, composed of 6 segments.

Mandibles with slender 3-jointed palp, the third joint of which is longer than second, cutting edge expanded and divided into 7 teeth; molar tubercle small, with no true triturating surface. First maxillae with inner plate small and broad and bearing a single spine on apex; outer plate narrow, moderately long, sides parallel to near distal end where plate tapers, inner margin of apex armed with about 12 broad, curved spines; palp 2-jointed, first joint as broad as long, second joint twice as long as broad, rounded at apex which is armed with a tooth and several spines. Second maxillae with inner plate narrow at base and inner edge oblique and slightly convex; outer plate narrow, somewhat longer than inner plate, bearing 3 or 4 spines on narrow apex and fine setules on inner margin. Maxillipeds with inner plate long and narrow, having lateral margins parallel and with rounded apex provided with 2 toothlike spines, extending as far as apex of first joint of palp; outer plate rather large, extending to middle of second joint of palp, oval in form, twice as long as wide, outer margin strongly convex, the distal portion of which bears many fine setae, inner margin distally serrate, proximally bearing several submarginal spines, apex bearing large tooth and spine; palp 4-jointed, first joint longer than broad, with a few spines on outer distal corner and outer margin; second joint rather narrower than first, slightly longer than broad, with a few spines on distal margin; third joint about twice as long as wide and not more than half as wide as second joint, provided with spines on apex; fourth joint clawlike, about $\frac{1}{3}$ as long as third joint.

First gnathopods with oval epimeron, which is higher than long; second joint long, more than 3 times as long as broad with a few setae on anterior margin and apex; third joint not as long as broad armed with a few spines apically; fourth joint more slender than third, rounded apically, twice as long as broad, with fascicle of spines at apex; wrist triangular, broader than long, articulating with anterior margin of fourth joint, posterior margin prolonged distally to form a triangular process which extends to the middle of the hand parallel to its posterior margin; hand subtriangular, articulating with wrist by apex, anterior margin slightly convex, palm also slightly convex and passing into posterior margin by obtuse angle, marked by 2 prehensile spines, finely serrate and armed with submarginal spines; finger moderately strong, curved, slightly longer than palm, inner margin with fine teeth.

Second gnathopods with epimeron $1\frac{1}{2}$ times as high as long, ventral margin strongly convex; second joint very long and slender, more than 4 times as long as broad; third and fourth joints as in

first gnathopods; wrist with posterior margin greatly elongated to form slender triangular process which extends as far as apex of posterior margin of hand, which is much larger than that of first gnathopods, more triangular in form with palm at right angles to axis of joint and $\frac{2}{3}$ as long as anterior margin, and finely serrate, and with prehensile angle provided with 2 stout spines; finger long, curved, with fine teeth on inner margin.

Uropods, 3, biramous; terminal uropods extending beyond others, with outer ramus shorter than inner and somewhat shorter than peduncle which is slender.

Telson slender, triangular, entire.

The species was represented by several specimens about 3 mm. long from Flatts Village in sand from low water to 2 fathoms, and also from Castle Harbor in dead coral.

Della Valle recorded the species from the Gulf of Naples at 5 fathoms.

Leucothoe spinicarpa (Abildgaard, 1789), Boeck, 1860.

1789. *Gammarus spinicarpus*. Abildgaard, in O. F. Müller, Zool. Danica, vol. 3, p. 66; pl. 119, fig. 1-4.

1860. *Leucothoe spinicarpa*. Boeck, Bemaerk. norske Amphip. Forhandl. ved de Skand. Naturforsk., p. 654.

Eyes compound, reniform, of medium size.

First antennae scarcely $\frac{1}{3}$ as long as body, slightly longer than second; peduncle about $2\frac{1}{2}$ times as long as flagellum; first joint moderately stout, cylindrical; second of about same length but more slender; third joint hardly more than $\frac{1}{4}$ as long as second and scarcely to be differentiated from first joint of flagellum which is short and composed of 8 or 9 segments; accessory flagellum 1-jointed, rudimentary. Second antennae with short flagellum; third joint of peduncle short, twice as broad as long; fourth joint long and slender; fifth joint about $\frac{2}{3}$ as long as fourth; flagellum about as long as last joint of peduncle and composed of about 7 segments.

Mandibles without molar tubercle but with incisive plate well dentated and with numerous spines on spine row; palp well developed, first joint short, with small process on inner margin; second joint long with spines on inner margin; third joint somewhat longer than first and provided with a few spines on rounded apex. Lower lip with plates broad and rounded. First maxillae with inner plates small, triangular and with single spine on apex; outer plates moderate with usual spines on oblique distal margin; palp 2-jointed, somewhat longer than outer plate, armed apically with a few spines. Second maxillae

with outer plates curved, slender and longer than inner plates which are more or less tapering and provided with rather long spines on inner margin. Maxillipeds with inner plate rudimentary, provided with 4 odontoid spines apically; outer plates likewise rudimentary, represented by small process bearing sharp spine; palp 4-jointed, all of which are provided with slender spines on the inner and distal margins, first and second joints much wider distally than proximally



Fig. 3. *Leucothoe spinicarpa* (Abildgaard).

and subequal; third joint somewhat club-shaped, about as long as preceding joint; fourth joint in form of nail bearing single cilium on inner concave margin.

First gnathopods with epimeron small, rhomboidal, having antero-ventral angle prolonged slightly; second joint rather long and stout, and broadest at middle, with short spines on both anterior and posterior margins; third joint moderately long, twice as long as broad and broader distally than proximally; fourth joint somewhat shorter than third and more slender; wrist large, oval, not much longer than broad but bearing by a prolongation of posterior margin a long slender, slightly curved spur which extends as far as distal

end of hand and which forms a true chela with hand, anterior margin of spur provided with a few short cilia; hand long and slender of nearly uniform width throughout, palm not marked off definitely from posterior margin; finger slender and of usual form.

Second gnathopods with oval epimeron longer than high; second joint moderately long with anterior margin straight and provided with a few slender spines; third joint about as broad as long; fourth joint very short, somewhat cup-shaped with distal end broader than proximal; wrist weak, bearing a long shell-like process distally and posteriorly which is provided with many slender setae and into which the proximal portion of the hand fits; hand oval, with posterior margin rather more convex than anterior, palm also convex, not differentiated from posterior margin, bearing distally 3 or 4 tooth-like convexities, hand provided with fascicle of spines apically; finger long and slender, curved and pointed.

Epimera increasing in height to fourth; third being shortest and terminating rather acutely ventrally; pereopods without spinning glands, ending in unguiform dactyls.

Uropods, 3 pairs, biramous, first and third pairs projecting beyond middle pair; rami subequal except in second pair where outer ramus is rather shorter than inner, more or less styliform; peduncles of first and second equal respectively to rami in length; peduncle of third pair rather longer than rami.

Telson long and slender, triangular, tapering uniformly to acute apex, 3 times as long as broad, entire.

Length 8 mm.

Numerous specimens were present in the collection from Harrington Sound, from Flatts Village from low water to 2 fathoms, and from Castle Harbor where they were found in dead coral.

The species is very widely distributed over the North Atlantic, being reported from the Arctic Ocean, Norway, the British Isles, the Azores, France, the Mediterranean. Sometimes it occurs in the branchial sac of Ascidians.

Stenothoe marina (Bate, 1857), Boeck, 1870.

1857. *Montagua marina*. Bate, Ann. & Mag. Nat. Hist., Ser. 2, vol. 19, p. 137.

1870. *Stenothoe marina*. Boeck, Forh. Videnskabs-Selsk. Christiania, 1870, p. 139.

Eyes large, compound, subtriangular.

First antennae $\frac{2}{3}$ as long as body, peduncle short with first joint rather stout, tapering somewhat; second joint slightly shorter than

first, cylindrical; third joint short, hardly to be distinguished from first segment of flagellum, which is made up of about 20 segments which are longer than broad; no accessory flagellum. Second antennae slightly shorter than first; peduncle nearly as long as flagellum; fourth joint somewhat longer than fifth.

Mandibles rather broad, without palp and molar tubercle; principal and secondary cutting edges denticulated; numerous spines in spine row. First maxillae with inner plate small, triangular, furnished with single setule apically; outer plate short, tapering slightly toward apex, with very minute setules on inner margin and 4 or 5 stout



Fig. 4. *Stenothoe marina* (Bate).

spines on apical margin; palp stout, 2-jointed, with second joint rounded and provided with numerous teeth and spines apically, proximal joint only slightly shorter than second. Second maxillae with plates normally developed, but with inner plate having a single setule. Maxillipeds with inner plate reduced to a slight eminence and outer plate entirely absent so that maxilliped appears to be made up of very small inner plate and a 5-jointed palp, of which all the joints are cylindrical except the terminal one which tapers to a slender point and bears fine cilia on the inner margin.

In male, first gnathopods much smaller than second; epimeron moderate in size; second joint long and slender of uniform width throughout; third joint cylindrical, slightly longer than broad; fourth joint large, more or less cup-shaped with distal margin long and oblique and posterior margin, which bears a few spines, much longer

than anterior; wrist triangular, about as broad as long, provided with spines on distal margin and posterior apex; hand oval with distal portion more slender than basal portion and with palm long and oblique, very finely serrate and furnished with long slender spines and 4 prehensile spines, finger moderate with concave margin serrate.

Second gnathopods with moderate epimeron which is higher than long with small tooth on postero-ventral angle; second joint long and slender; third joint cup-shaped and wider distally than proximally; fourth joint much wider distally than proximally with posterior distal angle acute, articulating with wrist by anterior margin; wrist triangular and broader than long, provided with a few spines on posterior apex; hand oval, about twice as long as broad with palm long and oblique and bearing near middle a triangular process, also provided with spines and setae and 2 prehensile spines; finger long and slender.

Pereiopods with epimera large, that of fourth being largest; pereiopods slender, provided with unguiform dactyls and without spinning glands.

Uropods, 3 pairs; first extending beyond second which in turn extends beyond the third pair; first and second biramous, third with single ramus; rami styliform, subequal, and somewhat shorter than peduncle; rami of terminal uropods stouter than others.

Telson entire, triangular, longer than wide with lateral margins slightly convex and provided with 4 stout spines on each side.

There was a single male specimen in the collection which measured about 3 mm. in length.

The species has been recorded from the North Atlantic and North Sea and from the Adriatic at a depth of from 19 to 47 fathoms.

***Stenothoe valida* Dana, 1853.**

1853. Dana, U. S. Expl. Exped. vol. 13 II, p. 924, pl. 63, fig: 1.

Eyes small, compound, reniform, situated between first and second antennae.

First antennae moderately long and slender with flagellum about twice as long as peduncle; first and second joints of peduncle cylindrical and subequal in length and each about as long as head, third joint less than $1\frac{1}{2}$ as long as second; flagellum made up of about 20 segments which are short proximally but become longer and more slender distally. Second antennae shorter than first in female (flagellum broken off in single male specimen at hand) with gland cone small and inconspicuous, third joint cylindrical and slightly longer

than broad, fourth joint long and cylindrical, fifth joint somewhat shorter than fourth; flagellum made up of about 17 segments, less than twice as long as peduncle.

Mandibles without palp or molar tubercle, but with incisive plate moderate. First maxillae with very small, triangular inner plate bearing single spine apically; outer plate rather broad and short, having 4 or 5 rather larger spine teeth on distal margin; palp 2-jointed, first joint short, second joint rather large, about 3 times

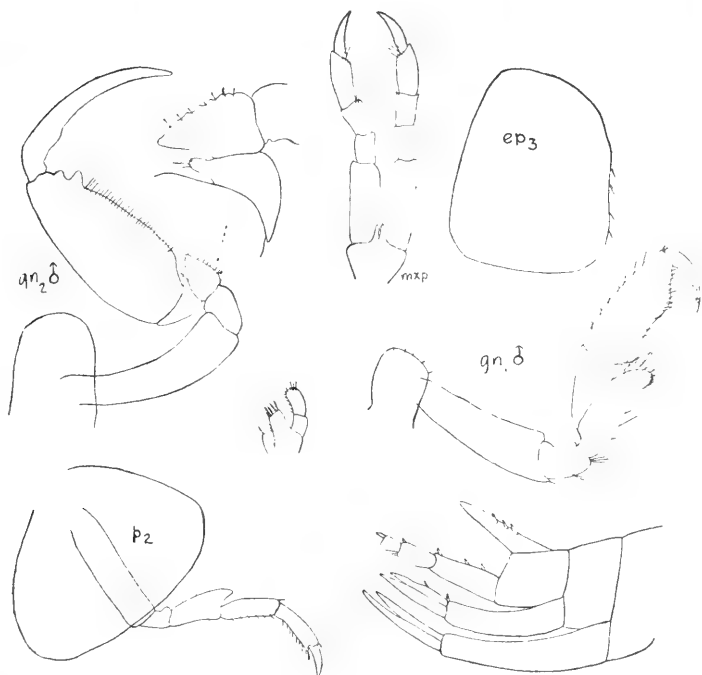


Fig. 5. *Stenothoe valida* Dana.

as long as first, rounded apically and provided with short setae on apex and inner margin. Maxillipeds with inner plates rudimentary and outer plates wanting; palps 4-jointed, rather long and slender, first joint rather short, slightly longer than broad, second joint longer than first, cylindrical, third joint clawlike and slender, as long as third.

In male, first gnathopods rather small, with very small epimeron having a few setae on ventral margin, second joint long and slender; fourth joint oblong with free anterior margin very short and posterior

margin forming an oval lobe which is provided with cilia posteriorly and spines distally, wrist triangular, shorter than fourth joint, with a few long spines on distal apical angle; hand subrectangular rather narrow, with anterior and posterior margins parallel and with moderate palm somewhat oblique, serrated and provided with a few spines, prehensile angle bearing a few stout spines; finger of usual form and moderate size.

Second gnathopods with epimeron higher than long and with ventral margin rounded; second joint moderately long and slightly curved; third joint cylindrical, about twice as long as broad; fourth joint longer than broad, with posterior margin convex and provided with about 6 rounded processes and a few short setae, wrist exceedingly small, triangular; hand large, suboval, anterior margin convex, straight posterior margin, which serves as palm, provided with 2 strong processes near articulation of finger, palm provided with many slender setae; finger long and very slender and rather strongly curved, with 2 slight processes near proximal end of concave margin.

First pereopods with moderate epimeron which is subrectangular and rather higher than long with ventral margin very finely serrate; fourth joint rather broad with posterior margin straight and anterior margin convex and projecting distally to form rather strong triangular process; fifth joint about as long as fourth, and more slender; sixth joint rather longer than preceding with straight posterior margin provided with rather stout spines; finger clawlike. Second pereopods with very large triangular epimeron, greatly expanded ventrally and with ventral margin gently rounded. Third pereopods with second and fourth joints expanded; third, fourth, and fifth pereopods with very small epimera; all pereopods closely resembling each other in distal segments.

Uropods, 3 pairs; first and second pairs biramous with rami styli-form; third pair projecting slightly beyond the other two, with single 2-jointed ramus, not as long as peduncle, the distal one of which bears a blunt projection apically and is longer than the proximal.

Telson triangular, rather prominent, entire, with 3 lateral spines on each side.

Length 5 mm. The species was represented by a male and a female specimen.

The female is much smaller than the male and differs from it principally in that the hand of the second gnathopod is broader and the palm is shorter and devoid of the 2 toothlike processes near the finger.

The species has also been reported from Rio Janeiro and possibly from the Mediterranean.

Pariphinotus gen. nov.

Body depressed and ridged dorsally.

First and second antennae short; first without accessory flagellum; flagella of both short.

Mandibles without molar tubercle or palp, principal cutting edge denticulated. Lower lip without inner plates. First maxillae with obsolete palp and without inner plates. Second maxillae with inner and outer plates coalesced except at apex. Maxillipeds with short, truncated inner plates not reaching as far as second joint of palp, apical margin with 3 spine teeth; outer plates broad and rounded, unarmed, extending nearly to distal end of second joint of palp which is moderate in size and made up of 4 joints, the terminal one of which is unguiform.

Gnathopods simple; epimera low.

Third pleopods with 2 rami and with peduncle expanded to form arm-like process tipped with 3 coupling hooks.

Uropods, 2 pairs, biramous. Telson semicircular, entire, thick.

The genus is closely related to *Iphinotus* (Stebbing) but has only 2 pairs of uropods which are both moderately stout whereas in *Iphinotus* the first is slender and the second stout.

Pariphinotus tuckeri sp. nov.

Head provided with broad, square rostrum with rounded corners and with prominent lateral lobes which bear the large, prominent, compound eyes.

Antennae short; first being slightly longer than second, with flagellum very short; first antennae with first joint of peduncle much broader distally than proximally and about as broad as long; second joint about $\frac{3}{4}$ as long as first and about $\frac{1}{2}$ as wide, with outer margin produced slightly distally; third joint about $\frac{2}{3}$ as long as second, cylindrical in form; flagellum short, about as long as second joint of peduncle, made up of 2 joints of which the terminal one is very short and the proximal one longer than last joint of peduncle, provided with setae distally. Second antennae with flagellum like that of first; third joint of peduncle cylindrical, about as broad as long; fourth joint twice as long as broad; fifth about same length as fourth but narrower.

Mandibles oblong with dentated cutting edges, 3 anterior teeth large, posterior ones small; molar tubercle and palp absent, spine

row with single spine. Lower lip without inner lobes but with very broad outer ones. First maxillae without palp or inner plate; outer plate armed on distal oblique margin with the usual forked, toothlike spines. Second maxillae with outer and inner plates coalesced except distally where a cleft separates the two; apical margin with a few short setae. Maxillipeds with plates well developed and 4-jointed palp; inner plates narrow, subrectangular, reaching scarcely as far as apex of first joint of palp, truncated, armed apically with 3 short spine teeth; outer plates broad, reaching as far as middle of second joint of palp, inner margin straight, outer margin strongly

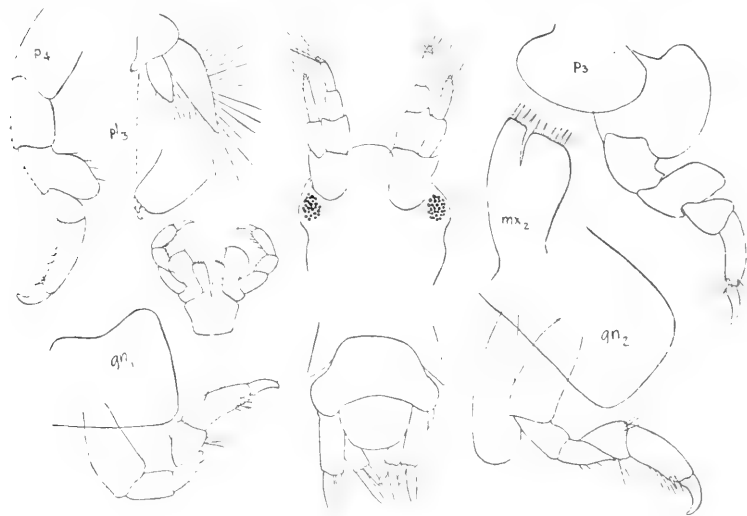


Fig. 6. *Pariphinotus tuckeri* sp. nov.

convex, armed only with single seta on inner apex; palps with first joint twice as long as wide, second joint slightly longer than first with setae on inner margin, third joint cylindrical, as long as second, with a few setae on inner margin toward distal end, terminal joint slender, unguiform.

In male, first gnathopods with large epimeron, produced slightly anteriorly; second joint moderately stout; third slightly longer than broad; fourth slender, somewhat cup-shaped with posterior convex margin provided with several setae; wrist triangular, about as broad as long with short posterior margin bearing a fascicle of setae; hand simple, as long as fourth and fifth joints together, tapering slightly, distal posterior angle provided with stout spine and several setae; finger stout and curved.

Second gnathopods with subrectangular epimeron higher than long, having rounded angles; second joint short and stout becoming uniformly broader distally; third joint slender, twice as long as broad; fourth joint narrower and shorter than third with posterior margin convex and longer than anterior; wrist, hand and finger as in first gnathopod.

Epimera diminishing in height posteriorly, that of first pereopod being slightly lower than that of second gnathopod; fourth joints rather broad, due to formation of lobe on anterior margin in anterior group of appendages and on posterior margin in posterior group; third, fourth, and fifth pereopods with second and fourth joints broad; sixth joints of all pereopods provided with stout spine at apex.

Second and third pleopods with both rami well developed and with peduncle bearing a stout prolongation medially which is provided with 3 coupling hooks at apex.

Uropods, 2 pairs, biramous; peduncle of both pairs cylindrical and extending to same distance posteriorly; rami styliform with somewhat rounded apices, outer one much longer and broader than inner one; outer margin of outer ramus of first with sparse setae, apex with single spine; second uropods with rami slightly longer than those of first, both rami with outer margin very finely serrated and provided with apical spine.

Telson semicircular, not extending as far as peduncles of uropods; margin entire.

Back provided with a rather conspicuous ridge; abdomen rather small.

No sexual dimorphism.

Length 5 mm.

The species was represented by a male and a female collected by Dr. W. G. VanName in 1901.

***Colomastix pusilla* Grube, 1861.**

1861. Grube, Ein Ausflug nach Triest und dem Quarnero, Berlin, 1861.

Eyes small, round.

First antennae short and stout, slightly longer than second; peduncle, stout and nearly twice as long as head; flagellum rudimentary, consisting of 3 very short segments which are provided with rather long setae; first joint of peduncle slightly longer than either second or third, which are subequal in length, cylindrical

and diminishing in thickness from first to third. Second antennae also with rudimentary flagellum; third joint of peduncle rather stout and tapering very slightly; fourth joint longer than third and more slender, slightly wider distally than proximally; fifth joint cylindrical and longer than fourth, with row of setae on lower margin.

Epistome elongated in front, in form of slender cone. Upper lip large and strong with distal margin bilobed. Mandibles with elongated body, principal cutting edge divided into 5 long slender teeth which are serrated distally; molar tubercle large, cylindrical; palp wanting. Lower lip apically broad, center prominent. First maxillae strikingly broad, inner plate wanting; outer plater short with distal

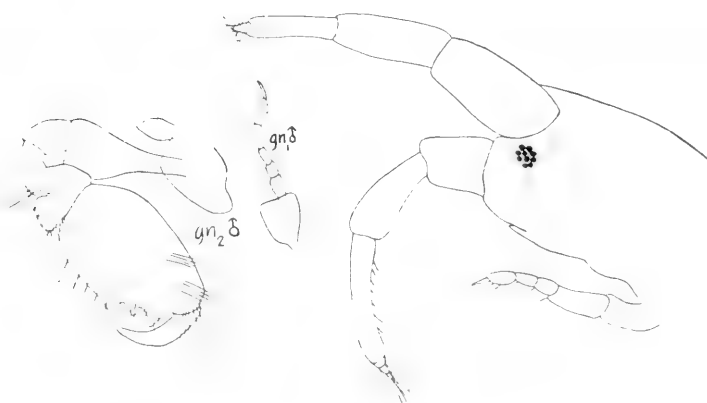


Fig. 7. *Colomastix pusilla* Grube.

margin provided with 3 odontoid spines; palp 1-jointed, curved to apex and terminating acutely so that inner margin of palp strikes against distal margin of outer plate, thus forming a true chela. Second maxillae formed of single plate, the distal margin of which is divided into 2 lobes, a small rounded one externally and a broader one medially, both of which are provided with setae. Maxillipeds very strongly developed; inner plates fused on middle line to form slender triangular plate; outer plates moderately broad but not very long, extending just beyond distal end of first joint of palp, inner margin smooth and unarmed; palp 4-jointed, slender, with first two joints cylindrical and second joint slightly longer than first, third joint a little longer than preceding, rather fusiform with a few setae on inner margin. fourth joint clawlike and about as long as second joint.

In male, first gnathopods strongly atrophied, rudimentary; epimeron triangular; second joint rather broader distally than proximally; third joint rather longer than usual; fourth, fifth, and sixth joints scarcely distinguishable, last joint forming very weak claw.

Second gnathopods with strongly developed hand; epimeron more or less oval, not large; second joint very slender at base but broadening regularly to distal end where anterior margin is produced to form a rather large rounded lobe; third joint small; fourth much narrower than third with a distal triangular process; wrist triangular, cuplike, not as long as broad, with short posterior margin provided with a number of setae; hand suboval, about twice as long as broad, anterior margin convex, posterior margin about half as long as anterior, palm oblique and very irregular, bearing 3 deep rounded indentations and numerous setae of different lengths, anterior submargin and apex with several fascicles of setae; finger rather stout and curved, of usual form.

Pereiopods rather long and slender and subequal with epimera which are longer than high; second joint long and slender; third joint small; succeeding joints elongated and subequal; claws small. Pereiopods of posterior group with second joints slender in proximal half, strongly dilated in distal half; succeeding joints very similar to those of anterior pereiopods.

Uropods, 3 pairs, biramous, all extending to about same distance posteriorly; rami broad, styliform, slightly serrated on margins; rami in all uropods subequal.

Telson entire, suboval, rather longer than broad with apical margin very slightly indented.

The species was represented by a single male specimen 4 mm. long. It has been reported from the Mediterranean and the British and French coasts.

Panoploeopsis gen. nov.

Posterior margins of posterior thoracic and anterior abdominal segments produced to form median dorsal teeth. Rostrum acute; epimera 1-3 more or less acutely tapering, fourth with posterior margin produced to form pointed process.

Mandibles narrowly tapering to cutting edge, accessory plate narrow, no spine row, molar tubercle rudimentary, palp 3-jointed. Lower lip rather elongate, without inner plate and with anterior margins of outer plates entire. First maxillae with inner plate bearing setae on inner margin and apex, outer plate rather long and nar-

row, palp 2-jointed, not reaching apex of outer plate. Maxillipeds with inner and outer plates long and narrow, outer fringed on distal part of outer margin, palp 3-jointed, first joint not as long as second and third together.

First and second gnathopods very slender, hands simple. Pereiopods 3-5 with second joint well expanded.

Third uropods with narrowly lanceolate rami, not extending as far as others. Telson broadly incised at apex.

The genus differs from *Panoploea* (G. M. Thomson) notably in the fact that the outer plates of the lower lip are not incised, in the shape of the second joint of the palp of the maxilliped and in the simple gnathopods.

***Panoploeopsis porta* sp. nov.**

Eyes circular, compound, rather small, ocelli closely crowded together.

Rostrum well developed, extending beyond first joint of peduncle of first antennae; interantennal lobes prominent, triangular.

First antennae shorter than second, with peduncle rather more than half as long as flagellum; first joint cylindrical and longer than second which in turn is longer than third joint; flagellum slender, made up of about a dozen segments which are provided with numerous threadlike setules. Second antennae much stouter than first, second joint with long slender conical process on dorsal side extending nearly as far as distal end of third joint which is slightly longer than broad; fourth and fifth joints subequal, cylindrical; flagellum about as long as last 2 joints of peduncle together.

Upper lip very long and slender. Mandibles elongated and slender toward apex, cutting edge very long, divided into 6 very short teeth, the apical one being the longest; secondary cutting plate very slender; molar tubercle rudimentary; palp 3-jointed, first joint slightly longer than broad and with rounded process apically, second joint long and slender, of uniform breadth throughout, third joint stouter and shorter than second, with a few short setae on inner margin and with outer margin slightly convex. Lower lip very much elongated and very narrow, with no inner plates and with mandibular processes rather short and with inner margin of outer plate entire. First maxillae with very slender 2-jointed palp not extending as far as apex of outer plate which is rather narrow and triangular with distal margin very oblique, provided with the usual toothed spines; inner plate small, triangular, with setae on inner margin. Second maxillae very long and slender, outer plates longer

than inner and with outer and inner margins parallel; inner plate triangular. Maxillipeds with 3-jointed palp of which the first is slightly longer than the second and as long as the third which terminates subacutely; outer plates moderately long with inner margin straight, outer margin convex and apex rather slender; inner plates moderate, terminal margin transverse and armed with plumose spines.

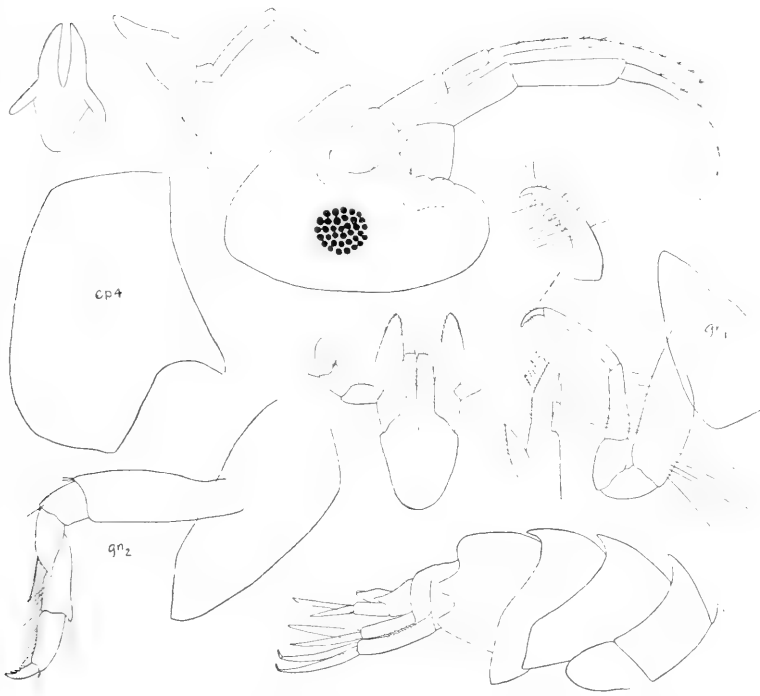


Fig. 8. *Panoploeopsis pmta* sp. nov. (*Ep 4* is upside down.)

In female, first gnathopods with rather high epimeron, twice as high as long, triangular, with slight notch on anterior margin; second joint moderately stout with long setae on anterior and on distal third of posterior margin; third joint slightly longer than broad; fourth joint about as long as third and slightly stouter; wrist slender, tapering toward distal end, about 3 times as long as broad; hand more slender than wrist and longer, anterior and posterior margins nearly parallel, simple; finger short, curved, with concave margin divided into about 6 hooked teeth and with numerous setae.

Second gnathopods with epimeron rather higher than that of first and more than twice as high as long, terminating acutely ventrally; second joint moderately stout; third joint about as broad as long; fourth joint about twice as long as broad with apex acutely pointed and with long slender setae on distal portion of posterior margin; wrist longer than hand and triangular with distal margin transverse and with anterior margin produced slightly distally; hand simple, about as long as fourth joint, tapering slightly to distal end, provided with row of short setae on posterior margin; finger short and stout with serrations and setae on concave margin.

Epimeron of third pereopod similar to that of second gnathopod; that of fourth much higher and longer, terminating ventrally in acute angle and with posterior margin concave proximally to accommodate succeeding epimeron, and with acute process ventral to recess; fifth epimeron longer than high with ventral margin bilobed; seventh epimeron smaller than sixth, both suboval in form.

Sixth and seventh thoracic segments and first 3 abdominal segments more or less keeled and with posterior margin produced to a sharp process in mid-dorsal line. First and second abdominal segments with lateral margins produced to form triangular lobes; third abdominal segment with posterior margins of lateral portions produced to form 2 stout, rather blunt projections.

Uropods, 3 pairs, biramous, with rami styloform; first pair extending slightly beyond second and third pairs which extend to same distance; peduncle of first pair longer than that of second and provided with row of sharp spines on dorsal margin, rami equal and as long as peduncle, each with terminal spine; second pair similar to first but without spines on peduncle; third pair with outer ramus shorter than inner, peduncle somewhat more than half as long as inner ramus.

Telson about twice as long as broad, with apex divided into 2 triangular lobes whose apices are rather widely separated from each other.

Length 7 mm.

The species was represented by a single female collected by J. M. Jones.

Eusiroides crassi Stebbing, 1888.

1888. Stebbing, Rep. Challenger, vol. 39, p. 977, pl. 90.

Eyes moderately large, compound, reniform, pigmented.

Antennae with calceoli on flagella; first antennae moderately slender, peduncle very short with first joint slightly longer than broad

second joint slightly shorter and narrower, third joint shorter and narrower than second; flagellum made up of about 15 segments, each of which is provided with setae on distal margin; accessory flagellum made up of 1 joint which is not as long as first joint of principal flagellum. Second antennae somewhat shorter than first; peduncle short, last 2 joints longest and subequal, about twice as long as wide; flagellum scarcely as long as peduncle, composed of about 9 segments which are provided at distal ends with a few spines.

Mandibles with 3-jointed palp and with principal cutting edge not denticulate; secondary cutting edge divided into 4 slight, rounded teeth; 3 spine teeth on spine row; molar tubercle well developed; third joint of palp longest, second joint rather broad. First maxillae with 2-jointed palp. Maxillipeds with plates normally developed;

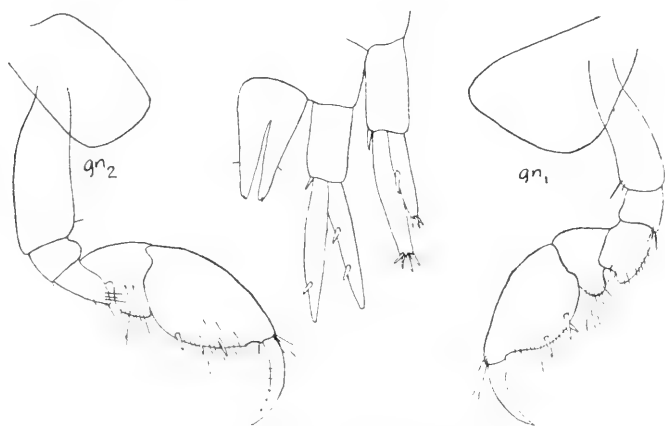


Fig. 9. *Eusiroides crassi* Stebbing.

inner plate rectangular, not as long as first joint of palp, inner margin with spine row with 4 or 5 spines; molar tubercle prominent but not very robust. Lower lip with lobes widely separated; inner plates very small; mandibular processes short and rounded. First maxillae with elongated palp 2-jointed, second joint nearly twice as long as first with 4 or 5 spines on apex and 1 on outer margin at middle; outer plate broad with 10 branched teeth on oblique distal end; inner plate small. Maxillipeds with 4-jointed palp of which the first joint is triangular, second joint articulating by inner margin and bearing 4 setae apically, second joint large, broader at distal end and with row of setae about distal margin and with inner margin densely covered with setae, third joint subrectangular, slightly

longer than broad and bearing 2 diagonal rows of setae on surface and with distal margin thickly set with long setae, not more than half as long as second joint, fourth joint unguiform, bearing 2 short setae on concave margin and nearly as long as third joint.

In male, first gnathopods with epimeron moderate, ventral margin smooth, posterior margin provided with a spiniform tooth ventral to which are 2 submarginal spines; second joint rather long and stout bearing a few long setae at distal end of anterior margin which is slightly concave; third joint about half as long as wide with fascicle of setae on distal posterior angle; fourth joint not as wide as third, about twice as long as wide, more or less rectangular with wrist articulating by anterior margin, the distal part of which bears 4 large spines, and posterior margin elongated to form a distal triangular lobe which bears 4 fascicles of setae; wrist broader than long, with posterior margin strongly convex so that segment is broader than hand, posterior margin much shorter than anterior and bearing several fascicles of setae; hand oval, smaller than that of second gnathopod, about twice as long as wide, with posterior margin continuous with palm and bearing about 9 fascicles of long flexible setae, palm oblique, and bearing 6 triangular processes which are accompanied by submarginal teeth and fascicles of setae, posterior margin very short; finger long and stout, of usual form.

Second gnathopods with epimeron higher than long with anterior and posterior margins parallel and with ventral margin slightly convex and bearing a few short setae; second joint longer than that of first gnathopod; third, fourth, and fifth joints as in first gnathopod; hand and finger more slender, but otherwise similar to first gnathopod.

Pereiopods slender, provided with dactyls; last pereiopods as long as preceding; epimera moderate, regularly convex ventrally.

Postero-lateral margins of third abdominal segment not serrated:

Uropods, 3 pairs, biramous; first pair with long slender peduncle provided with 5 or 6 spines on inner margin and one on apex, rami also slender and styliform with inner one slightly longer than outer one, extending as far as extremities of terminal uropods, rami nearly as long as peduncle; second uropods similar to first but with peduncle much shorter and with rami more tapering than in first, inner ramus rather stouter than outer and somewhat longer; terminal uropods extending well beyond telson, with rami subequal, laminar, $1\frac{1}{2}$ times as long as peduncle, both rami furnished with short setae and plumose spines on inner margin and 1 or 2 on outer margin.

Telson laminar, triangular, slender, cleft $\frac{2}{3}$ to base. In one of

the specimens at hand the right lobe was shorter than left and more rounded at apex. This may have been the result of injury. Each lobe with single spine near apex on outer margin.

Length 8 mm.

The species has been reported from the South Atlantic at a depth of about 500 fathoms.

***Pontogeneia verrilli* sp. nov.**

Eyes compound, reniform, closely approximated dorsally.

Antennae very elongate; first slightly longer than second; and about half as long as body, much more slender than second pair,

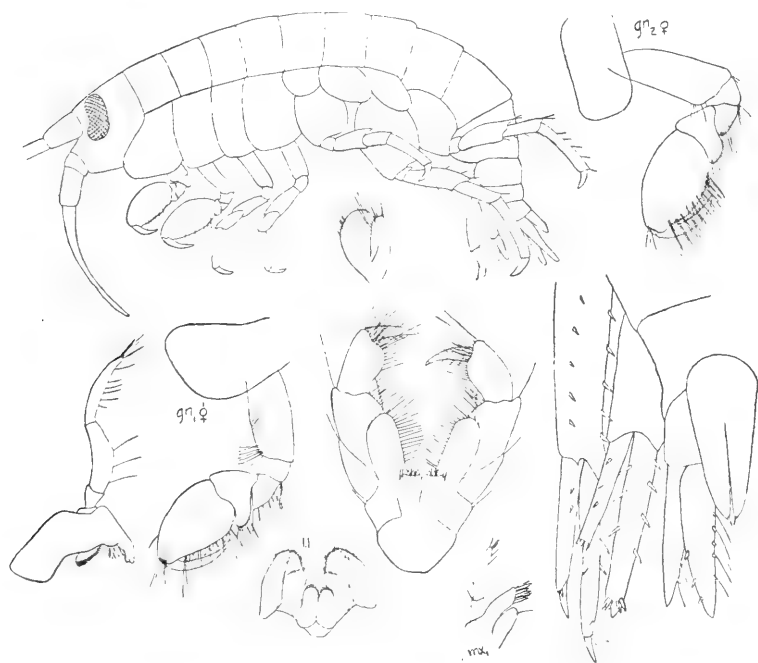


Fig. 10. *Pontogeneia verrilli* sp. nov.

peduncle rather short with joints increasing in length distally; flagellum made up of many joints which are very short toward the base but become longer distally, provided with calceoli. Second antennae with peduncle slightly shorter than flagellum and with second and third joints very short, fourth and fifth joints subequal in length, at least three times as long as second and third together; flagellum with joints very short.

Mandibles with 3-jointed palp of which the first is very short and broadens distally, second and third joints subequal but second much stouter, third joint tapering slightly and terminated by several slender spines; cutting edges denticulated; molar tubercle prominent: several spines on spine row. Lower lip with outer plates large and widely separated, inner plates large and oval; mandibular processes not large. First maxillae with inner plate oval and large, provided with single spine apically; outer plate moderately slender with distal margin very oblique and armed in usual fashion; palp long, 2-jointed, with second joint slender and tapering, with few spines on outer and inner margins and apex. Second maxillae with outer plate bearing single plumose spine apically and several simple ones on inner margin, rather slender and shorter than inner plate which is very broad and of oval form, with a few setae on inner margin. Maxillipeds with inner plates small and bearing 3 odontoid spines on transverse distal margin; outer plates rather large with outer and inner margins parallel and with apical margin rounded, bearing long setae on inner margin; palp 4-jointed and provided with unguiform spine apically; third joint with many setae apically where it is broader than at base; fourth joint with short setae on inner margin; second joint provided with flat laminar process along entire inner margin which bears long slender setae.

First gnathopods with subtriangular epimeron considerably higher than long; second joint moderately long and of uniform thickness, provided with group of spines at antero-distal angle: third joint short; fourth joint subtriangular with setae along posterior margin; wrist triangular, broader than long with setae on posterior margin; hand moderate in size, longer than wrist, oval, palm long and slightly convex, passing into short posterior margin by even curve, provided with about 6 large conical teeth and long setae alternating with them. apex of hand with fascicle of setae; finger long and slender.

Second gnathopods very similar in shape and size to first; hand slightly more slender and palm provided with greater number of teeth.

Epimera moderate; pereopods without spinning glands, with dactyls.

Three anterior abdominal segments with postero-lateral margins serrate.

Uropods, 3 pairs, biramous; first and second with rami styliform and inner longer than outer and with both rami provided with spines. first extending slightly beyond second and third, peduncle of first rather longer than rami, that of second considerably shorter;

third pair with rami rather broader and lamellar, tapering to acute point, inner ramus larger than outer, provided with slender setae.

Telson long and slender, twice as long as broad, cleft for $\frac{2}{3}$ of its length, each lobe provided apically with single spine, extending beyond peduncle of terminal uropod.

Length 7 mm. This species was represented in the collection at hand by several specimens some of which were found in dead coral from Castle Harbor.

Melita fresnelii (Audouin, 1876).

1876. *Gammarus fresnelii*. Audouin, Descr. Égypte, vol. I, iv, p. 93, Crust., pl. 11, fig. 3.

1875. *Melita fresnelii*, Miers, Ann. Nat. Hist., ser. 4, vol. 16, p. 75.

Eyes compound, circular, deeply pigmented in alcoholic specimens.

First antennae almost as long as body, longer than second antennae; peduncle more than half as long as flagellum, with first joint cylindrical, second joint longer and more slender than first; third joint very short; flagellum slender and made up of about 40 elongated segments; accessory flagellum made up of 5 segments. Second antennae extending to about middle of first antennae with peduncle somewhat longer than that of first; gland cone long and slender, reaching nearly as far as end of third joint which is longer than broad; fourth joint very long and slender; fifth subequal to fourth in length; flagellum rather long, made up of more than 14 segments.

Mandibles strong with all parts well developed; principal cutting edge denticulated; numerous spines on spine row; molar tubercle large and prominent; palp made up of 3 joints of which the first joint is short, second one moderately long, but shorter than the third and with setae along outer margin, third joint very slender, provided with many long setae on inner margin and apex. Lower lip with outer plates broad, rounded, and with anterior margin entire, inner plates moderate, mandibular processes short. First maxillae with inner plates slender and tapering, moderate, with 2 plumose spines on apex; outer plates large and curved with usual branched spines on oblique distal margin; palp 2-jointed with second joint broader apically and armed with spinelike teeth, apex of first joint provided with fascicle of setae. Second maxillae with oval plates, moderately broad; outer plates with slender setae on rounded apex; inner plates with slender setae on apex and inner margin and with an oblique row on outer surface. Maxillipeds with inner

plates rectangular, extending beyond first joint of palp and provided with plumose spines on inner and distal margins and also on distal margin with 3 odontoid spines, and submarginally at inner distal angle with 2 conical toothlike spines; outer plates moderate in size, not extending as far as second joint of palp, inner margin straight, outer margin convex, passing over to distal margin by even curve, inner margin provided with toothlike spines which increase in length toward the apex and gradually become long and slender spines on

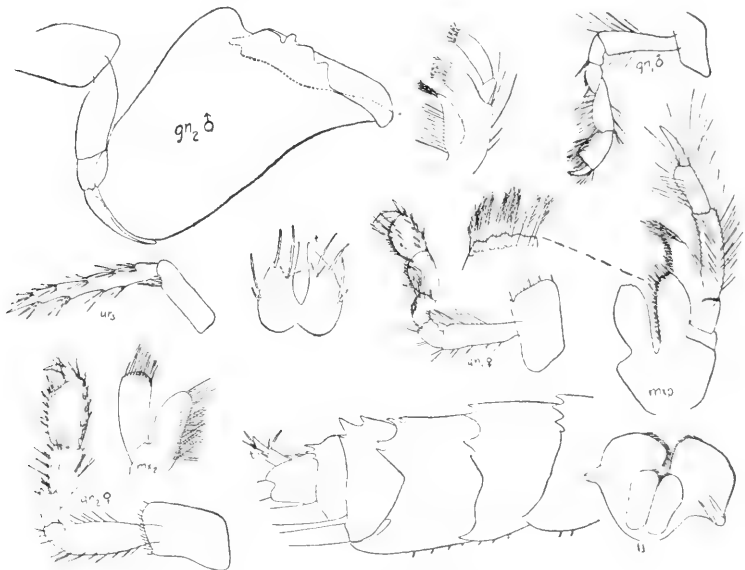


Fig. 11. *Melita fresnelii* Audouin.

distal margin; palp 4-jointed, first joint slightly longer than broad, second joint slender, broadest proximal to middle, 3 times as long as broad, provided with numerous fascicles of slender setae, third joint short and curved, larger at distal end than at proximal, fourth joint curved and tapering, with apical spine and a few large setae on inner margin.

In male, first gnathopods with small, rhomboidal epimeron; second joint long and slender, provided with long setae on anterior and posterior margins; third joint slender, slightly longer than broad; fourth joint small, broader distally and rounded, with fine cilia on posterior margin and with setae apically; wrist long, triangular, $2\frac{1}{2}$ times as long as broad with 5 or 6 fascicles of setae on posterior and distal margins; hand subtriangular, somewhat longer than

broad and broader distally than wrist, palm nearly transverse, provided with setae on posterior and distal portion of anterior margins and palm; finger stout and curved.

Second gnathopods with small rhomboidal epimeron which is higher than long; second joint rather long, extending well beyond epimeron; third joint short; fourth joint rather long with posterior margin convex and distal margin much longer than proximal; wrist rather short with posterior margin prolonged to form cuplike process in which the posterior margin of the hand fits proximally; hand very large and strong, broader distally, posterior margin prolonged apically to form strong fingerlike process which tends to make the hand chelate, palm transverse and bearing 3 strong rounded processes near articulation with finger which is strong and not greatly curved, except at apex where it closes past the fingerlike process of the hand, and which is broadest at middle.

In female, first gnathopods with quadrilateral epimeron having posterior margin forming a small triangular process and with ventral margin provided with setae and cilia; second joint long and slender with 5 fascicles of setae on posterior margin and numerous longer setae on distal $\frac{2}{3}$ of anterior margin; third joint slightly longer than broad; fourth somewhat longer than third with anterior margin very short and posterior margin long and provided near distal end with many very fine cilia and several stout setae; wrist longer than hand and as broad as hand, provided on posterior margin with numerous short setae which form a close set mass, and also with a few longer pectinate spines on posterior margin and numerous fascicles of setae near margin; hand subrectangular, less than twice as long as broad with posterior margin provided with many setae of different lengths, some of which are finely pectinate, palm finely serrate and armed with short submarginal spines, anterior margin with 4 fascicles of setae; finger of usual form having 2 curved spines on outer convex margin and with several short slender ones on concave margin.

Second gnathopods slightly stouter than first, with epimeron very similar to that of first but slightly higher; fourth segment with posterior margin prolonged to form a triangular process and provided with a few long setae; wrist quite similar to that of first gnathopod but larger, posterior margin furnished with fascicles of slender setae among which are a few finely pectinate ones; wrist as long as hand which is subrectangular, palm oblique with rounded prominence near articulation with finger, finely serrate, furnished also with numerous submarginal setae and with 3 prehensile spines,

anterior and posterior margins each with 6 fascicles of setae; finger strongly serrate and provided with 2 fascicles of setae near middle of outer convex margin.

Pereiopods with moderate epimera and with normal dactyls and no spinning glands.

Abdominal segments with ventral margins of anterior 3 prolonged posteriorly, first 2 to form simple triangular processes, third with ventral margin very much longer to form a slender process posteriorly; dorsal portion of posterior margins of abdominal segments deeply serrated to form 5 to 7 acutely pointed teeth.

Cropods, 3 pairs, biramous; first pair extending slightly beyond second, rami styliform, inner one longer than outer, peduncle slender, cylindrical, about as long as inner ramus, rami provided with spines on inner margin and apex; second pair similar in form to first but shorter; terminal uropods extending considerably beyond others, inner ramus rudimentary, outer ramus long and slender, more or less flat, about twice as long as peduncle, provided with fascicles of setae on outer and inner margins and apically.

Telson triangular, slender, lamellar, cleft $\frac{3}{4}$ to base with lobes rather dehiscent, provided with several sharp spines on outer margin and at apex, somewhat longer than broad.

Length 6 mm. Numerous specimens were at hand which were found at Flatts Village, in sand from low water to 12 feet; in Castle Harbor, among dead corals; and in Harrington Sound.

The species has been found on the coast of Brazil, Rio Janeiro, at Singapore at a depth of 9 feet, and according to Haswell it is very common at Port Jackson, New South Wales.

Melita planaterga sp. nov.

Eyes round, small, compound, deeply pigmented, situated well ventrally between first and second antennae.

First antennae long and slender, about $\frac{3}{4}$ as long as body; peduncle as long as flagellum; first joint of peduncle stout, more or less fusiform, second joint cylindrical and somewhat longer and more slender than first; third joint short, not more than $\frac{1}{3}$ as long as second; principal flagellum made up of about 18 slender segments; accessory flagellum short, 2-jointed. Second antennae somewhat shorter than first, but peduncle longer than that of first, with flagellum made up of about 7 segments and about as long as last 2 joints of peduncle, third joint of peduncle about as long as broad, fourth and fifth subequal in length, gland cone rather long and slender.

Upper lip with small median emargination. Mandibles with dentate cutting edges, prominent molar tubercle and slender 3-jointed palp, the second joint of which is the longest and the terminal joint of which tapers slightly and is a little shorter than second. Lower lip with inner plates distinct. First maxillae with numerous setae on inner plate and with outer plate armed in the usual way; palp 2-jointed with terminal joint broadened and rounded distally and armed with toothlike projections and setae. Maxillipeds with plates well developed and with 4-jointed palp; inner plates subrectangular,

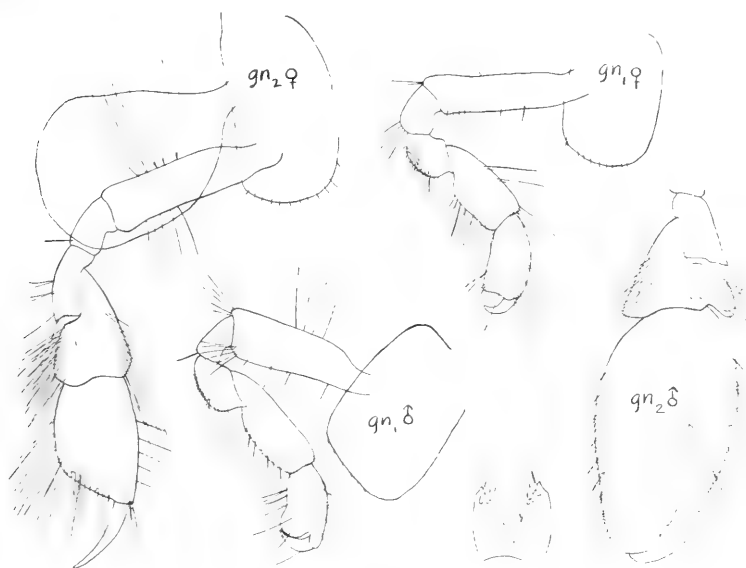


Fig. 12. *Melita planaterga* sp. nov.

long, extending nearly to middle of second joint of palp, distal margin transverse and provided with numerous setae; outer plates large, with outer and distal margins convex, inner margin straight and provided with spine teeth which become long and slender apically; second joint of palp 3 times as long as wide, cylindrical, third joint about $\frac{3}{5}$ as long as second, broader distally than proximally and bearing a rounded triangular process at middle of inner margin, rounded apex ciliated, fourth joint long and slender, unguiform.

In female, first gnathopods with oval epimeron, higher than long with ventral margin somewhat convex and provided with fine setae; second joint very long and slender with setae on both anterior and posterior margins; fourth joint short, posterior margin strongly convex

and provided with fine cilia and a few long setae; wrist triangular, twice as long as wide and longer than hand, anterior margin and distal portion of posterior margin parallel and with a few setae; hand subchelate, subrectangular, with palm transverse, about twice as long as broad; finger short and strongly curved. Second gnathopods with epimeron rather higher than first; second joint long and slender with numerous long setae on posterior margin and smaller number on anterior; fourth joint longer than third with posterodistal angle slightly produced; wrist triangular, nearly as broad as long, with dense setae on posterior margin and very long ones on anterior; hand oval.

In male, first gnathopods like female except that the wrist is much longer and the hand is broader at distal than at proximal end because of rounded lobelike process on posterior margin; palm very convex, bearing a rather marked rounded incision near hinge; finger short, thick, and somewhat curved. Second gnathopods with rounded epimeron which is higher than long; second joint moderately stout and with a few long setae on posterior margin; fourth joint about twice as long as broad with posterior margin somewhat produced to acute point; wrist triangular with posterior margin somewhat rounded and produced distally and provided with a series of transverse rows of setae; anterior submargin also with rows of setae; hand oval, nearly twice as long as broad with anterior and posterior margins of nearly equal convexity and provided with numerous fascicles of setae, palm provided with many long slender setae, rather convex and passing into posterior margin by even curve; finger rather long and stout and not greatly curved, capable of closing past palm.

Epimera of moderate size, fourth one largest, emarginate posteriorly; pereopods slender and increasing in length posteriorly, the last 2 being subequal; second joints of third to fifth pereopods well expanded with posterior margins finely serrate. Abdominal segments with posterior margin smooth, third segment with posterolateral margins entire.

Uropods 3 pairs, biramous; first and second pairs with lanceolate rami provided with a few stout setae on outer margin and fascicle of setae at apex; third uropods with inner ramus small, outer ramus greatly elongated and rather foliaceous, with margins slightly convex and apex blunt, provided with stout setae on both margins and apex.

Telson as broad as long, cleft to base, each lobe bearing triangular process distally and several setae.

Length 9 mm.

The preserved specimens were marked with irregular chocolate brown bands on posterior margin of body segments, the bands on the first 3 abdominal segments being especially broad; the telson, peduncles of uropods, and of antennae were marked with very minute brown spots and the proximal joints of pereopods bore irregular longitudinal brownish lines.

The specimens were collected in a brackish pond near Flatts Village.

***Ceradocus orchestipes* A. Costa, 1853.**

1853. A. Costa, Rendic. della Soc. Reale Borbon., Acc. delle Sci., Napoli, n. ser., vol. 2, p. 177.

Eyes compound, large, round.

First antennae about $\frac{3}{4}$ as long as body; peduncle rather long but shorter than flagellum, first joint moderately stout, cylindrical, second joint slightly longer than first, third joint rather short and slender; flagellum made up of 22 or more segments, the first of which is scarcely to be distinguished from terminal joint of peduncle; secondary flagellum made up of 5 segments. Second antennae shorter than first, flagellum rather short; gland cone rather long and slender, extending beyond distal end of third segment which is about twice as long as broad, fourth segment slightly longer than fifth, rather long and slender; flagellum made up of about 9 joints, about equal in length to last joint of peduncle.

Mandibles with all parts well developed; palp 3-jointed, first joint moderately long, broader at apex and bearing sharp spinelike process at inner distal corner, second joint longest, tapering slightly toward distal end and bearing 4 long setae on inner margin; third joint about $\frac{1}{2}$ as long as second with slender rounded apex which bears several long setae and is also provided with 2 setae on inner margin and 1 on outer; principal cutting edge divided into 2 rounded teeth; secondary cutting edge broad, made up of 4 equal teeth; 7 plumose spines on spine row; molar tubercle moderate. First maxillae with 2-jointed palp, second joint longer than proximal joint and broader at apex which is provided with numerous spines; outer plate large, with 6 or 7 branched and pectinate spines on oblique distal margin; inner plate broad, triangular, with inner margin provided with row of long plumose spines. Second maxillae of usual form, plates oval, subequal; outer plate with apex provided with setae; inner plate with setae on inner margin as well as apex. Maxillipeds with plates well developed; inner plate with apex truncate and outer and inner angles prolonged to form toothlike processes, apical

margin with many plumose spines; outer plate extending almost as far as second joint of palp with inner margin provided with toothlike spines which become longer toward rounded apex; palp with first joint slightly longer than broad, second joint very long and moderately slender having slender setae on inner margin, third joint short, with distal end larger than proximal; fourth joint with slender terminal spine as long as joint itself.

In male, first gnathopods with epimeron triangular, small; second joint moderately stout with short setae on anterior margin and several very long ones on posterior margin; third joint short with group of moderately long setae near distal end of posterior margin;

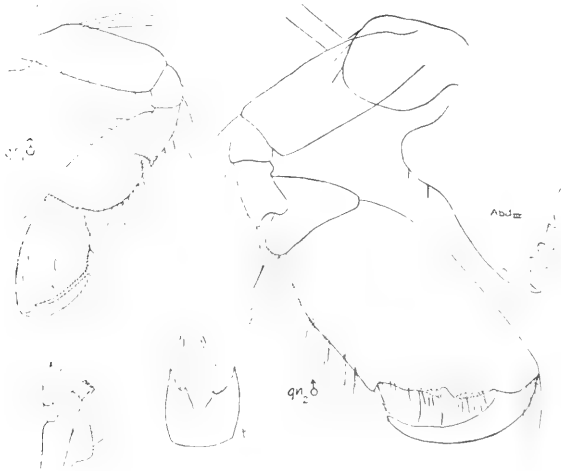


Fig. 13. *Ceradocus orchestipes* A. Costa.

fourth joint more or less rectangular with 4 fascicles of setae on posterior margin and group of setae on distal margin, both anterior and posterior margins produced distally to form small triangular processes; wrist very large, triangular, longer and broader than hand, posterior margin very convex and provided with many long setae which also are present on distal margin, anterior margin with 4 quite long setae; hand more or less oval with palm oblique and about as long as posterior margin which bears many setae, palm provided with numerous setae; finger of usual form moderately stout.

Second gnathopods with rectangular epimeron slightly higher than long; second joint short and stout with 2 long setae near proximal end of posterior margin and 1 at distal end and 1 near distal end

of anterior margin; third joint short; fourth about twice as long as broad, subrectangular; wrist small, triangular, broader than long with many long setae on convex posterior margin; hand very large, subrectangular, twice as long as broad, with palm oblique and having moderately deep notch near middle, prehensile angle with stout spine, palm provided with numerous submarginal setae, posterior margin with 6 fascicles of setae and apex with 5 or 6 long setae; finger curved, stout and of usual form.

Pereiopods with epimera of moderate size, of usual form and provided with dactyls but no spinning glands.

Uropods 3 pairs, biramous; first extending slightly beyond second, rami cylindrical, inner one slightly longer than outer, peduncle $\frac{1}{3}$ longer than rami, provided with sharp spines on inner margin; second uropods of essentially same form as first but with peduncle much shorter so that rami are slightly longer than peduncle; terminal uropods reaching much beyond the others, rami very long, equal, laminar, finger with spinules, apices narrowly truncate.

Telson flat, slightly longer than broad, with lobes widely separated, cleft $\frac{2}{3}$ to base; each lobe terminating in long acute process and bearing 2 long stout spines side by side on inner margin near apex.

Length 6 mm.

The species was represented by a number of specimens some of which were found in sand at Flatts Village from low water to 2 fathoms.

The species has been reported previously only from the Mediterranean.

***Ceradocus parkeri* sp. nov.**

Eyes, small round, compound.

First antennae long and slender, about $\frac{1}{3}$ as long as body, with rather long peduncle, about $1\frac{1}{2}$ times as long as flagellum which is made up of about 20 segments which are provided with long setae; accessory flagellum half as long as principal flagellum, made up of 6 or 7 segments; peduncle with first 2 segments cylindrical and equal in length, third joint less than $\frac{1}{5}$ as long as second and narrower. Second antennae about $\frac{3}{5}$ as long as first, with short flagellum made up of about 8 short segments, slightly shorter than last joint of peduncle, which in turn is about $\frac{1}{3}$ shorter than the fourth and is provided with setae on the lower margin, fourth joint cylindrical, with setae on lower margin, third joint about 3 times as long as broad, gland cone small and applied closely along lower margin of third joint.

Mandibles with principal and secondary cutting edges dentated and with numerous spines on spine row, molar tubercle robust; palp 3-jointed, with first joint rather short, second joint long and slender with row of long stiff setae on inner margin, third joint shorter and more slender than second with several very long setae on inner margin toward apex which is rather acute. Lower lip with inner plates broad and rounded, outer plates broad with entire margins, mandibular processes short and stout. First maxillae with 2-jointed palp, inner plate triangular with many setae on inner margin. Second maxillae with plates having apices rounded, outer plate larger than inner, both provided with setae on distal end. Maxillipeds with 4-jointed palp, the first joint of which is about as long as broad, the second is long and slender, cylindrical with setae on inner margin,

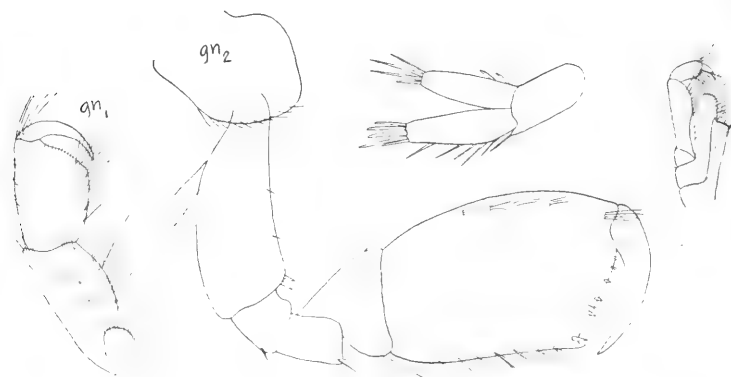


Fig. 14. *Ceradocus parkeri* sp. nov.

the third is less than $1/2$ as long as the second with the distal end rather broader than proximal and provided with setae on rounded apex, and the fourth joint is conical with a stout spine apically; outer plate rather well developed, extending nearly as far as apex of second joint of palp with outer margin rounded and inner margin provided with broad toothlike spines which become longer toward apex; inner plate moderate, rectangular, with distal margin transverse and provided with a few plumose spines and bearing triangular process on outer distal angle.

In male, first gnathopods with moderate epimeron, having antero-ventral angle prolonged slightly and provided with several spinules; second joint rather long, slightly broader distally than proximally and with a few setae on posterior margin; third joint short; fourth joint rather longer than broad, subrectangular, with rounded apex

bearing fascicle of setae; wrist rather large and subtriangular, twice as long as wide, with many fascicles of setae on posterior margin and on lateral surface, and stout spines on apex; hand shorter than wrist but about as wide, subrectangular with distal end wider than proximal and with palm slightly oblique, finely serrate and provided with short setae, posterior margin provided with 4 or 5 fascicles of long stout setae, prehensile spine present, anterior margin slightly convex and provided with 4 or 5 fascicles of setae; finger moderately stout and curved with few fine setules on concave margin.

Second gnathopods with subrectangular epimeron about as broad as long, with ventral margin provided with a few setae; second joint very stout with 2 long spines on proximal third of posterior margin and numerous fine setae on anterior margin and 2 short stout setae on anterior distal apex; third joint broader than long; fourth, subrectangular, twice as long as broad with single seta on postero-distal apex; wrist triangular, about as broad as long; hand stout, subrectangular, slightly broader distally than proximally, palm slightly oblique, provided with setae, prehensile angle produced to form curved toothlike process and provided with prehensile spine, posterior margin with about 8 fascicles of setae, anterior submargin with about 4 fascicles; finger of usual form, stout.

Epimera of moderate size; pereopods of moderate size and provided with clawlike fingers.

First 3 abdominal segments with posterior and lateral margins entire and rounded.

Uropods, 3 pairs, biramous; rami of first 2 pairs styliform and subequal, with large spines apically; third uropods with rami much longer than peduncle and somewhat flattened, outer ramus longer than inner, with rather long spines on outer margin and apex, inner ramus with long spines apically. Telson subrectangular, about as broad as long, divided to base, each lobe with several long stout spines on inner apex.

Length, 6 mm.

The species is represented by a single male specimen.

***Ceradocus colei* sp. nov.**

First antennae slender, longer than second, about half as long as body; peduncle about $\frac{2}{3}$ as long as flagellum which is made up of nearly 20 segments; first joint of peduncle swelling somewhat in thickness at middle, about 3 times as long as broad, provided with a few setae, second joint longer and more slender than first and provided with setae, third joint small, scarcely to be distinguished

from proximal joints of principal flagellum; accessory flagellum short, 2-jointed. Second antennae with flagellum about as long as last 2 joints of peduncle, made up of 8 or 9 elongated segments; gland cone rather stout and prominent, third joint slightly longer than broad, fourth joint cylindrical and about as long as first joint of peduncle of first antennae, fifth joint longer and more slender than fourth, both fourth and fifth joints with slender setae.

Mandibles as in *C. parkeri*. First maxillae with 2-jointed palp, of which the first is short and the second more or less clubshaped with short spines on rounded apex; outer plate slightly tapering in form, with usual spine teeth on distal margin; inner plate somewhat rounded with numerous setae on inner margin. Maxillipeds



Fig. 15. *Ceradocus colei* sp. nov.

with 4-jointed palp and outer and inner plates well developed; first joint of palp short, cylindrical, second joint cylindrical and about $2\frac{1}{2}$ times as long as broad, third joint slightly thicker distally than proximally, about twice as long as wide and of about the same thickness at widest part as second, provided with spines and cilia at apex, fourth joint clawlike, curved, with short setae on inner margin; outer plate extending as far as apex of second joint of palp with inner margin straight and provided with abundant setae, outer margin and apex convex; inner plates extending scarcely to middle of second joint of palp, apex truncated and provided with short setae which become more slender and extend along distal half of inner margin.

In female, first gnathopods with moderate rhomboidal epimeron

having anterior ventral angle somewhat produced anteriorly; second joint rather long and slender with margins parallel and with anterior margin having several long setae near proximal end and group of shorter ones at distal end, posterior margin with group of setae at distal end; third joint small, with few setae on posterior margin near distal end; fourth joint broader distally than proximally, with posterior margin especially strongly convex toward distal end and provided with a fascicle of rather long setae apically and ciliated for $\frac{3}{4}$ of its length; wrist $\frac{1}{3}$ longer than hand, somewhat over $\frac{1}{3}$ as broad as long, of uniform width throughout except at proximal end where articulation with fourth joint is oblique, anterior margin with fascicle of pectinate spines at anterior apex, posterior margin with 6 or 7 fascicles of setae, some of which are pectinate, surface of wrist with several groups of setae; hand subrectangular, slightly narrower at proximal end than at distal end and narrower than wrist, anterior margin slightly convex and provided with several fascicles of setae, posterior margin with several groups of setae, palm transverse, slightly convex with submarginal setae toward posterior margin; finger of usual form, extending as far as prehensile angle of hand.

Second gnathopods with epimeron twice as high as long with ventral margin evenly rounded; second joint moderate with long setae on posterior margin and a few near distal end of anterior; fourth joint with posterior margin elongated to form triangular projection; wrist triangular, about $1\frac{1}{3}$ times as long as broad, with anterior and posterior margins provided with numerous fascicles of setae; hand suboval, somewhat longer than wrist and of same width, anterior margin twice as long as posterior, with numerous fascicles of setae, posterior margin with long setae, passing into oblique convex palm by even curve, prehensile angle with several stout setae, palm provided with setae of various lengths; finger moderately long and curved with setae on middle of convex margin.

Pereiopods and epimera as in *C. parkeri*. Third abdominal segment with postero-lateral angle prolonged somewhat posteriorly, posterior margin entire.

Uropods, 3 pairs, biramous; rami of first and second styliform, those of first pair extending beyond second; third pair long and rather flattened.

Telson subrectangular, about as long as broad, divided to base, each lobe somewhat acutely pointed and provided with group of several setae of different lengths.

Length 5 mm. There was a single female specimen in the collection.

Maera inaequipes (A. Costa, 1851), Stebbing, 1906.

1851. *Amphithoe inaequipes*, A. Costa, Cat. Crost. Ital., p. 45.

1906. *Maera inaequipes*, Stebbing, Das Tierreich, Lief. 21, p. 435.

Eyes small, rounded, compound, deeply pigmented in alcoholic specimens. Interantennal lobes rather prominent and rounded.

First antennae about $\frac{1}{2}$ as long as body, slender, peduncle longer than flagellum, second joint rather longer than first which tapers slightly; third joint very short; flagellum made up of about 18 segments gradually increasing in length distally; accessory flagellum long, made up of 7 segments, more than half as long as principal flagellum. Second antennae extending to about middle of flagellum



Fig. 16. *Maera inaequipes* (A. Costa).

of first; peduncle about as long as that of first antennae; gland cone rather long and acutely pointed, extending to middle of next segment; third joint more than $\frac{1}{2}$ as long as fourth which is the longest and is very slender; fifth joint about $\frac{3}{4}$ as long as fourth; flagellum about as long as fourth joint of peduncle, consisting of about 10 segments.

Mandibles triangular, with all parts well developed; palp 3-jointed, third joint longest, tapering somewhat in form; second joint slightly shorter than third, about 3 times as long as broad, cylindrical; first joint longer than broad; principal and secondary cutting edges both denticulated, secondary plate rather broad; molar tubercle very large, 5 or 6 spines in spine row. Lower lip broad, having anterior margin of outer plates incised; inner plates large; mandibular

processes elongate. First maxillae with 2-jointed palp having proximal joint broader apically, distal joint about 3 times as long as broad, rounded apically and bearing a number of setae at apex; outer plate not reaching to middle of second joint of palp, with truncated apical margin which bears about 8 branched and furcate spines; inner plate small, triangular, bearing about 4 plumose spines apically. Second maxillae with oval plates having apices rounded; outer plate slightly longer and broader than inner one. Maxillipeds with 4-jointed palp and well developed plates; second joint of palp rather, long about 3 times as long as broad, third joint about twice as broad as long with rounded apex, fourth joint conical, armed with terminal claw nearly as long as segment itself; outer plate oval, extending about $\frac{2}{3}$ to distal end of second joint, provided with odontoid spines along inner margin which become longer toward apex and on the broad distal margin; inner plate rectangular having plumose spines on distal margin which bears a small triangular process at outer corner and a single toothlike spine apically and externally.

In female, first gnathopods with small epimeron produced to form acute angle anteriorly, ventral margin slightly notched and provided with fine setae; second joint of moderate proportions with long setae on posterior margin; third joint longer than broad, bearing group of setae on posterior margin; fourth joint rectangular, bearing rounded process on postero-distal angle, distal end provided with row of short setae and a number of longer ones; wrist very long, as long as hand, triangular, articulating with anterior margin of fourth joint, anterior margin indented slightly near distal end, posterior margin provided with 8 or 9 fascicles of setae and bearing, proximal to articulation of hand, a row of pinnate spines; hand rather small, regularly oval, posterior margin more convex than anterior, palm oblique passing by even curve into posterior margin, with short submarginal setae and several fascicles of longer setae and 3 prehensile spines; finger rather long and curved.

Second gnathopods with small rhomboidal epimeron having setae on antero-ventral margin; second joint of same form as that of first with long slender setae on anterior margin at proximal and distal ends; third joint short; fourth rectangular, as in first; wrist very small, triangular, with lobe on free posterior margin which is rounded and provided with numerous fine setae; hand very large and oval, twice as long as broad and broader than wrist, palm variable in character but moderately long, often with 3 rounded processes near articulation with finger and provided with numerous submarginal setae of various lengths, and with posterior margin produced to

form triangular process behind which the extremity of finger fits; finger very long and strong. (Palm usually transverse and with rounded notch in the middle; in one specimen the hands on the 2 sides were quite different.)

Gnathopods of male quite similar to those of female.

Pereiopods of moderate length, those of posterior group being rather stout and fourth and fifth being subequal, all furnished with tricuspidate dactyls; epimera of moderate size, subrectangular; third to fifth pereiopods with second joints moderately expanded, posterior margin produced slightly distally.

Uropods, 3 pairs, biramous; first pair with moderately long peduncle, bearing stout spines on outer margin, inner ramus slightly longer than outer; second uropods shorter than first, extending posteriorly about as far as first pair; third pair of flattened form, extending scarcely beyond others, peduncle short, rami with truncated apices, provided with fascicles of setae on outer margin and apex of outer ramus which is rather broader and longer than inner.

Telson longer than broad divided nearly to base, lobes widely dehiscent; each lobe terminating in triangular point bearing small toothlike process at base of outer margin, and accompanied by toothlike spine.

Third abdominal segment with postero-lateral corners not serrate. Length 7 to 8 mm.

The species was represented by numerous specimens which were rather variable. Specimens were collected at Flatts Village in sand from low water to 2 fathoms, in dead coral in Castle Harbor, in corallines from Bailey Bay, and in Harrington Sound. It has been previously recorded from the Mediterranean and the Azores.

Maera rathbunae Pearse, 1908.

1908. A. S. Pearse, Proc. U. S. National Mus., vol. 34, p. 29.

Eyes round, small, compound, deeply pigmented.

First antennae longer than second, with peduncle longer than flagellum, first joint rather stout, slightly tapering in form, second joint very slender, longer than first; third joint short, hardly to be distinguished from first joint of principal flagellum, which is made up of about a dozen segments; accessory flagellum as long as first 7 segments of principal flagellum, composed of many joints. Second antennae with rather short flagellum, about as long as fourth joint of peduncle, made up of 8 segments; gland cone prominent, extending nearly to end of third joint of peduncle; fourth joint slightly longer than fifth, and like the fifth provided with long setae.

Mandibles with all parts well developed, palp 3-jointed, the terminal joint of which is bluntly styliform, shorter than second and provided with long setae on inner margin. First maxillae with 2-jointed palp of uniform thickness throughout and with apex rounded and provided with short setae; outer plate of usual form with forked and branching toothlike spines on oblique distal margin; inner plate



Fig. 17. *Maera rathbunae* Pearse.

triangular, of moderate size, with 4 setae on apex. Second maxillae with subequal, oval plates having setae on distal margins. Maxillipeds with 4-jointed palp and well developed plates; inner plate subrectangular, extending somewhat beyond first joint of palp with outer margin slightly convex and with distal margin armed with plumose spines; outer plate rather large, armed with setae on inner and distal margins, oval, extending nearly as far as second joint of palp which is the longest and cylindrical; third joint about $\frac{1}{2}$ as long

as second and slightly longer than first; fourth joint clawlike, about as long as third.

In male, first gnathopods with suboval epimeron and moderately slender second joint which bears several long setae on posterior margin; third joint short; fourth joint slightly longer than broad with numerous setae on rounded apical margin; wrist rather large and triangular, more than twice as long as broad, with posterior margin well rounded and with distal margin provided with numerous setae, anterior margin produced to form a triangular process; hand about as wide as wrist but not so long, suboval in form, posterior margin more convex than anterior margin and passing into oblique palm by an even curve, palm slightly irregular in contour and provided with setae of various lengths; finger moderately long and slender.

Second gnathopods with small, subrectangular epimeron; second joint fairly short and third joint a little longer than broad; fourth smaller than third with anterior margin much longer than posterior; hand very large, subtriangular in form with base of triangle forming palm, posterior margin produced to form a triangular process, palm very irregular in contour, more or less incised in posterior half and with rounded prominence near articulation with finger provided with stout spine; finger very large and strong, of curved form with concave margin bearing a slight eminence toward middle.

Epimera low, suboval in form, third slightly bilobed ventrally, second epimeron highest.

Uropods, 3 pairs, biramous; first pair with peduncle longer than the styliform rami; second pair rather stouter than first, rami provided with numerous stout setae; third pair with short peduncle and rather broad, subrectangular lamelliform rami of which the inner one is shorter than the outer one and provided only at apex with setae, outer ramus also with setae on outer margin, third uropods extending slightly beyond first and second.

Telson rectangular, slightly broader than long, incised for $\frac{2}{3}$ of its length with the lobes widely dehiscent, lobes truncate and distal angles provided with several setae.

Length of single male specimen which was in the collection, 5 mm.

The species has been reported by Pearse from the Gulf Stream, off Key West, Florida, in 98 fathoms, Station 7279, U. S. Bureau of Fisheries, steamer *Fish Hawk*; and 122 fathoms, Station 7296.

Maera tinkerenis sp. nov.

Eyes rather large, circular, with ocelli very widely separated. Interantennal lobes of head not prominent. Back sparsely setose.

First antennae with long peduncle, somewhat longer than flagellum, more than $\frac{1}{2}$ as long as body; first joint of peduncle tapering slightly, rather longer than head, bearing on proximal half of lower margin 3 setae equidistant from each other and on upper margin, numerous very fine setae, apically a single seta and fascicle of setae; second joint more slender than first and slightly longer, provided with fascicles of setae on upper margin and short setae on lower; third joint less than $\frac{1}{3}$ as long as second; principal flagellum composed of many segments, provided apically with short

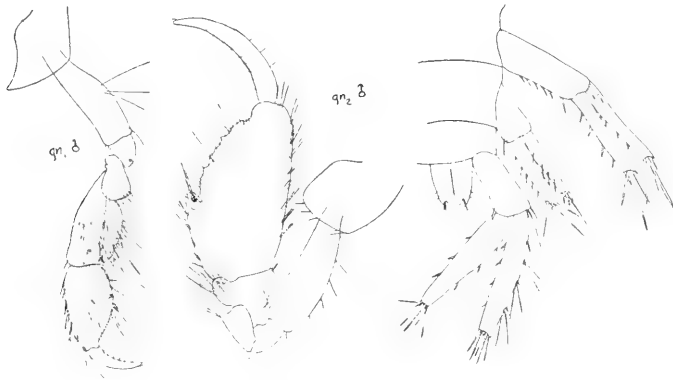


Fig. 18. *Maera tinkerenis* sp. nov.

setae; accessory flagellum long, made up of 5 segments. Second antennae only slightly longer than peduncle of first, with gland cone long and slender; third joint about 3 times as long as broad; fourth and fifth joints slender, fourth being slightly longer than fifth; flagellum scarcely longer than last joint of peduncle, made up of about 6 segments.

Mandibles with denticulated cutting edge and all parts moderately developed; palp 3-jointed, with second joint longest; third joint of tapering form and provided with long setae on inner margin. Lower lip of ordinary form, rather broad and furnished with strong mandibular processes. First maxillae with 2-jointed palp of uniform width and with square apex and furnished with 7 or 8 plumose spines, proximal joint of palp with numerous very fine setae on outer margin; outer plate extending beyond middle of second joint of palp, some-

what tapering with apex truncate and provided with about 8 branched (antler-like) spines; inner plate small, triangular, with 3 spines apically. Second maxillae of usual form with oval plates, outer plate broader distally, inner one broader proximally. Maxillipeds with 4-jointed palp, second joint long and slender, more than 4 times as long as broad, third joint as long as fourth including terminal spine; outer plate rather narrow and slender, reaching nearly to end of second joint of palp, provided on inner margin with row of closely set toothlike spines which become longer toward distal end of plate where they become plumose; inner plate rectangular, with plumose spines on apical margin and distal portion of inner margin, which bears at distal end a submarginal toothlike spine and external to this a fascicle of simple setae.

In male, first gnathopods with epimeron which is higher than long and which projects strongly anteriorly, with a short seta just behind anterior ventral corner; second joint moderately long with several setae near middle of posterior margin; third joint slightly longer than broad with fascicle of setae near distal end of posterior margin; fourth joint short with posterior margin very convex so that joint is $\frac{2}{3}$ as broad as long, posterior margin with numerous setae on distal portion; wrist subrectangular, widening somewhat toward distal end, as broad as hand and slightly longer, posterior margin with 8 or 9 fascicles of slender setae which increase in length distally, surface of wrist provided with many fascicles of short simple setae and longer pectinate spines; hand oval, with more or less convex palm passing by even curve into posterior margin, provided with 2 prehensile spines, posterior margin with 3 fascicles of setae, palm finely serrated and provided with numerous submarginal setae, surface of hand and anterior margin further furnished with fascicles of setae; finger of usual form with single seta on outer margin near base and 5 or 6 blunt spines on inner margin.

Second gnathopods with epimeron about as broad as long, with ventral margin slightly convex and furnished with 4 or 5 setae; second joint long, with posterior margin convex and furnished with 4 or 5 setae placed at equal distances from each other; third joint somewhat longer than broad; fourth joint twice as long as broad, broadening somewhat distally, with posterior margin elongated to form a sharp projection having 2 setae at base; wrist triangular, not as wide as hand, with posterior margin rounded to fit internal to projection on fourth joint, rounded portion covered with setae of various lengths, the longest being on the margin; hand large,

oval, nearly twice as long as wide, with anterior margin having a number of fascicles of setae, palm oblique, more than $\frac{1}{2}$ as long as hand, posterior margin furnished with 5 or 6 fascicles of setae, prolonged to form a notch behind which the end of the dactyl fits, notch provided with fascicle of long setae and with 2 spines bearing cilia-like appendages, palm serrated and provided with submarginal setae of various lengths; finger of usual form with 3 slender setae on convex margin and 9 submarginal filiform spines on internal margin.

Pereiopods moderately slender, seventh slightly longer than sixth; epimera of moderate size with ventral margin convex and furnished with a few setae.

None of the segments dentate dorsally.

Postero-inferior margin of third abdominal segment entire.

Uropods, 3 pairs which are biramous, first extending as far as second and having rami subequal and longer than peduncle, the inner margin of which is furnished with 6 spines and apex with several rather long spines, rami with 4 spines on inner margin and group of longer ones at apex; second uropods with peduncle shorter than that of first and also relatively much shorter than rami which are subequal and stouter than those of the first; terminal uropods extending far beyond others, with peduncle short and provided with setae on distal margin, outer ramus somewhat longer than inner, of uniform width, furnished externally with 4 notches in which are fascicles of setae, inner margin with 4 short spines and fascicle of long spines apically, inner ramus of slightly tapering form with outer margin furnished with 3 spines and inner with 4 and apex with a fascicle of setae.

Telson longer than broad, deeply cleft, each lobe being incised to form a triangular notch in apex and armed with one spine and fine seta.

Length 4 mm.

The species was represented in the collection by several males from Harrington sound.

Elasmopus rapax A. Costa, 1853.

1853. A. Costa, Rendic. della Soc. Reale Borbon., Acc. delle Sci., Napoli, n. ser., vol. 2, p. 175.

Body moderately compressed and stout, back without carinae or spines but with sparse, very fine setules. Postero-lateral angle of first 2 abdominal segments about 90° , third segment rather rounded

and slightly acute; ventral margins of abdominal segments provided with rather stout spine about in the middle.

Eyes compound, reniform, composed of many ocelli, deeply pigmented in alcoholic specimens.

First antennae longer than second, with flagellum rather shorter than peduncle, second segment of peduncle slightly longer than first and more slender; third segment about $\frac{1}{2}$ as long as second; flagellum made up of many segments; accessory flagellum 2-jointed,

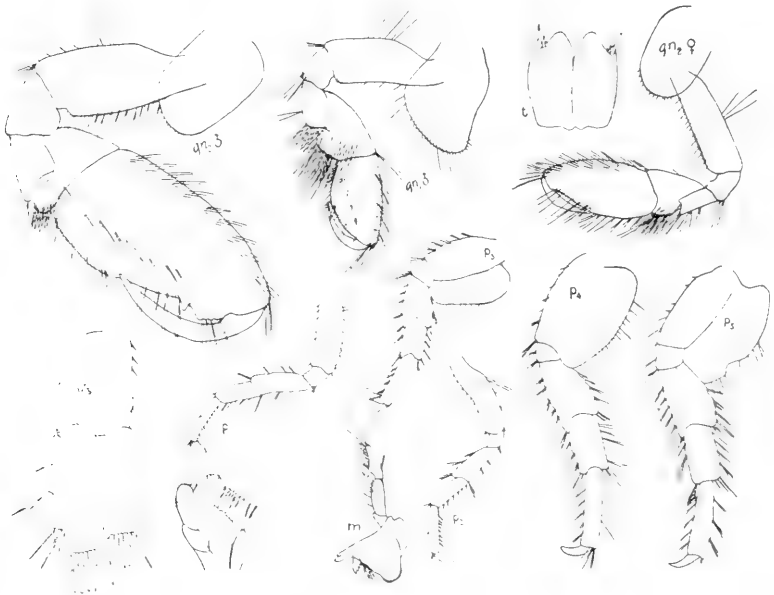


Fig. 19. *Elasmopus rapax* A. Costa.

shorter than first 2 joints of principal flagellum. Second antennae with gland cone long and slender; third joint as broad as long; fourth and fifth joints subequal; flagellum rather short, made up of about a dozen segments.

Upper lip rounded sharply with fine cilia on anterior margin and ventral surface. Mandibles with 3-jointed palp, principal cutting edge denticulated, and large molar tubercle; first joint of palp short, second rather strong with several setae on inner margin, third segment blade-like, slender proximally, broadening abruptly, outer margin convex, inner edge straight and furnished with setae apically; secondary cutting edge also denticulated; spine row with 7 spines.

Lower lip with outer plates rather widely separated, mandibular processes moderately long; inner plates moderate. First maxillae with inner plate triangular with 2 plumose spines apically; outer plate large, provided with pectinate and branched toothlike spines, terminal margin straight and oblique; palp 2-jointed, terminal joint twice as long as first and moderately stout, apex rounded and provided with number of finely serrated spines. Second maxillae with inner plate nearly as long as outer and with margins parallel and apex rounded; outer plate broader than inner, slightly broader distally and with inner margin longer than outer. Maxillipeds with inner plates narrow, twice as long as wide, apex straight and inclined slightly toward middle and provided with 14 or 15 plumose spines; outer plate much larger than inner with median margin provided with numerous toothlike spines and setae and distal margin with about 6 plumose spines; palp 4-jointed with last joint clawlike; second joint twice as long as first and broader at distal end than at proximal, rather broad, provided with setae on distal half; third joint a little longer than first with apex provided with ciliated knob and abundant long setae on distal half.

In male, first gnathopods smaller than second; second joint rather slender with margins parallel and provided with few short setae; third joint about as long as wide provided with a fascicle of setae on distal margin; fourth joint rather more slender than third, with anterior and posterior margins parallel, posterior margin prolonged to form triangular process which is twice as long as broad; wrist triangular, cup-shaped, rather broader than hand, posterior margin thickly beset with setae; hand oval, with palm slightly convex, finely serrated toward apex, provided with numerous setae; dactyl about $1/2$ as long as hand, of usual form with fine cilia on concave margin and a single seta near base of outer margin.

Second gnathopods with moderately developed second joint, provided with short setae on posterior margin and longer ones on straight anterior margin; third joint slightly longer than wide with small convex process at anterior end and furnished with fascicle of setae apically; fourth joint with posterior margin twice as long as anterior and provided with fascicle of setae distally; wrist very short and broad, about as broad as long and about as broad as hand, posterior margin very convex and provided with very many setae of moderate length, articulating with short anterior margin of fourth joint; hand slightly more than twice as long as broad, oval; palm rather oblique, bearing rather broad, flat process near articulation with finger and having several teeth, anterior and posterior

margins with numerous fascicles of setae; finger of usual form, curved and pointed, about $\frac{1}{2}$ as long as hand and provided with number of short cilia on inner concave margin.

First gnathopods of female similar to those of male; second with second joint more slender, furnished with many short setae on anterior margin and several long ones on posterior margin; third joint longer than broad; fourth twice as long as broad, subrectangular with several fascicles of setae on posterior margin; wrist cup-shaped, nearly as broad as long with free portion of posterior margin closely beset with many long setae; hand long, oval, as wide as wrist, with fascicles of setae on anterior and posterior margins, palm oblique, passing by regular curve into posterior margin, provided with setae and with prehensile spine; finger of usual form, long.

Pereiopods with moderate epimera, provided ventrally with a few setae, no spinning glands, appendages gradually increasing in length posteriorly; pereiopods 3 to 5, very robust.

Uropods, 3, biramous; first uropods with inner ramus longer than outer, extending as far as second uropods; terminal uropods having rami lamellar and projecting beyond anterior ones.

Telson deeply cleft but lobes not widely dehiscent, longer than broad, bearing at outer posterior corner a short process and stout spine; inner corners of lobes rounded.

The species was represented by numerous specimens, some of which bore the locality labels of Bailey Bay where they were found in corallines, the "Ship Channel," Flatts Village, in sand, low water to 2 fathoms, Castle Harbor in dead coral, and Harrington Sound. The species has been recorded previously from the British Isles, Christianiafjord, the Atlantic coast of France, the Azores, and the Mediterranean.

***Elasmopus magnispinatus* sp. nov.**

First antennae somewhat more than $\frac{1}{2}$ as long as body, fairly stout, with flagellum having abundant setae, peduncle slightly longer than flagellum, with first joint rather stout and broadest in middle; second joint slightly shorter than first and much more slender, provided with setae; third joint more than $\frac{1}{2}$ as long as first; principal flagellum stout, made up of about 10 rather short segments; accessory flagellum 1-jointed, rudimentary. Second antennae very short, about as long as flagellum of first; gland cone fairly prominent, third joint of peduncle as long as broad; fourth and fifth joints subequal in length, fifth narrower than fourth and tapering slightly;

flagellum about as long as last joint of peduncle, made up of 4 or 5 segments.

Mouth parts as in *E. pocillimanus*.

In male, first gnathopods much smaller than second, with moderately large rhomboidal epimeron; second joint rather stout with proximal end slender; third and fourth joints short, fourth about twice as long as broad with posterior margin convex apically where it is provided with short setae; wrist large, triangular, rather wider than hand and with a number of long setae, some of which are pectinate; hand suboval in form, somewhat more than twice as long as broad, palm rather oblique, passing into posterior margin by even curve, prehensile angle with prehensile spine, posterior

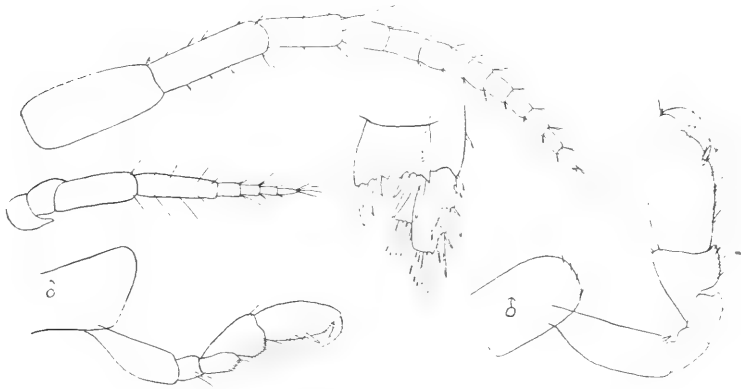


Fig. 20. *Elasmopus magnispinatus* sp. nov.

margin and palm provided with rather long, slender setae; finger curved and of moderate proportions.

Second gnathopods with suboval epimeron, rather higher than long and having ventral margin rounded; second joint strong, bearing single stout spine at anterior apex; third joint short; fourth joint subrectangular with distal margin bearing a small, triangular process; wrist triangular, about as broad as long and broader than hand, with posterior margin provided with long setae; hand and finger similar to those of first gnathopod but larger.

Epimera moderate; pereopods 3 to 5, very stout; third abdominal segment with posterior lateral angle produced slightly to form triangular process. Dorsal region of body segments provided with sparse hairs.

Uropods, 3 pairs, biramous; first and second with styliform rami,

first extending slightly beyond second and as far as third; rami of first subequal, and not as long as peduncle, provided on dorsal margin and apex with stout spines; second uropods with rami similar to those of first but not longer than peduncle; third uropods with lamelliform rami, outer one larger than inner and provided with fascicles of spines on outer margin and truncated apex.

Telson about as broad as long, rectangular, deeply incised, each lobe bearing a process at inner angle and with group of 3 or 4 stout spines on distal margin.

Many individuals occurred in the collection, the largest of which were about 4 mm. in length.

Sexual dimorphism not marked.

Elasmopus pocillimanus (Bate, 1862), Della Valle, 1893.

1862. *Maera pocillimanus*. Bate, Cat. Brit. Mus., p. 191, pl. 34, fig. 7.

1893. *Elasmopus pocillimanus*. Della Valle, Fauna und Flora des Golfes von Neapel, vol. 20, p. 733; pl. 1, fig. 4; pl. 22, fig. 23-25.

Eyes compound and placed well toward anterior surface of face; interantennal lobes not prominent.

First antennae longer than second, not more than $\frac{2}{3}$ the length of body; peduncle moderately long, first 2 segments subequal, third about $\frac{1}{2}$ length of second; flagellum about as long as peduncle, made up of about 21 segments; accessory flagellum 2-jointed. Second antennae only slightly longer than peduncle of first; gland cone slender and pointed, extending beyond apex of third segment which is not as broad as long; last 2 segments of peduncle subequal, long and slender; flagellum short, not as long as last 2 joints of peduncle, made up of 10 joints.

Mandibles with 3-jointed palp, first joint of which is short, second of moderate length and only slightly shorter than third which becomes broader near the middle and tapers toward the apex like a knife blade, inner margin of tapering portion armed with closely set row of short setae of equal size and 2 or 3 longer ones apically; cutting edge dentate, molar tubercle prominent. First maxillae with 2-jointed palp, the terminal joint of which is longer and thinner than first and armed with a number of moderately stout spines at the rounded apex; outer plate of moderate size, with 6 branching and pectinate spines on apical margin; inner plate small, triangular, with 2 plumose spines on apex. Second maxillae of usual form. Maxillipeds with plates well developed; inner plate rectangular with plumose spines and spine teeth on apical margin; outer plate not

extending to distal end of second joint of palp, margin armed with setae which are short and stout on proximal part of inner margin, becoming elongated and toothlike toward the apex and long and slender on apical portion of outer margin; palp 4-jointed, third joint provided with ciliated knoblike process at apex, fourth joint curved and clawlike and armed with a terminal seta.

First gnathopods of male very small; epimeron rather small, rhomboidal, inferior anterior angle projecting forward considerably,

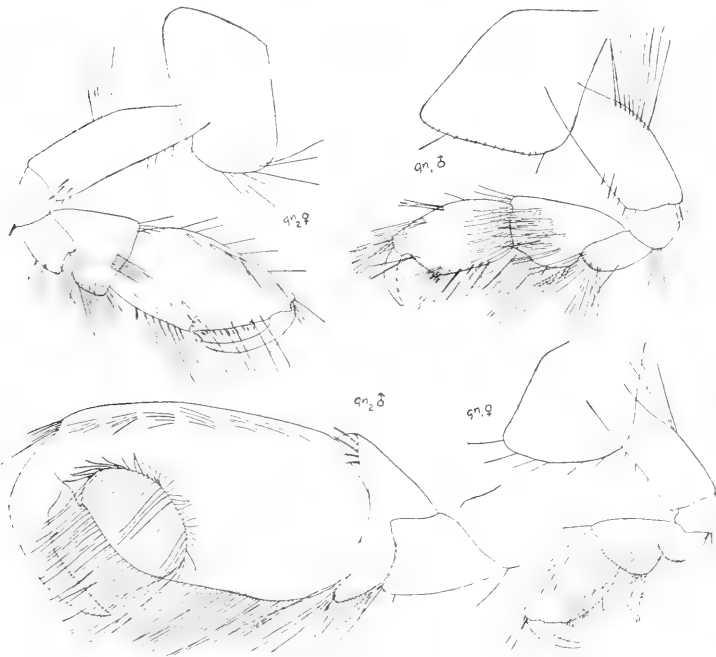


Fig. 21. *Elasmopus pocillimanus* (Bate).

ventral margin armed with many short setae and 2 long setae; second joint moderately stout, projecting considerably beyond epimeron, provided on convex hind margin with about 9 rather long, slender setae and at distal end of posterior margin with several shorter ones, some of which are pectinate; third and fourth joints small, each provided apically with many long setae, front margin of fourth joint straight, forming articulation with wrist which is nearly as long as hand and slightly broader; wrist provided with many long setae on posterior and apical margins and on lateral

surface, posterior margin rather strongly convex, distal margin straight and at right angles to anterior margin: hand subrectangular with 5 or 6 fascicles of setae on posterior margin and 3 or 4 on anterior which is more convex than posterior; palm short, oblique, armed at prehensile angle with 3 or 4 spine teeth, finely serrate and armed with many submarginal setae; finger of usual form with a few setules on inner concave margin.

Second gnathopods very large in the male, with small epimeron which is $\frac{2}{3}$ as long as high, lower margin convex and armed with many short submarginal setae and slender spines; second and third joints very similar to the respective joints of the first gnathopod but larger and stouter; fourth joint relatively short with posterior margin twice as long as anterior; wrist triangular, not as long as broad, with a considerable process on posterior margin which fits into the concave apical margin of preceding joint and is armed with many long, slender setae; hand very large, rectangular, about twice as long as wide; posterior margin, which continues by a regular curve into the palm, armed with many long setae; anterior margin with many fascicles of setae including one at apex; palm oblique and hollowed to form concavity like shallow bowl which is bordered with many slender setae, and into which fits the finger which is strongly curved and stout.

In female, first gnathopods very similar in form and size to those of male, but somewhat more slender; fourth joint shorter than in male and wrist relatively shorter and broader with posterior margin armed with many long pectinate setae, hand and finger similar to male.

Second gnathopods quite similar to first but larger; wrist armed with many setae on posterior margin which is more angular than in the first gnathopod; hand oval, twice as long as broad, armed with numerous long setae and short spine teeth; 3 or 4 longer spine teeth at angle between palm and posterior margin; finger moderately long and slender with a single seta on convex margin.

Pereiopods of usual form, terminating in curved dactyls; epimera of moderate size increasing to fourth; second joints of last 3 pereiopods normally dilated; posterior limbs stout and seventh as long as sixth.

Uropods biramous; third extending beyond others and rami expanded into subequal plates armed with many setae on apex, outer plate with outer margin also provided with setae.

Telson rectangular, not longer than broad, cleft nearly to base, the 2 halves widely dehiscent, each armed with 2 setae at apex

which is rather deeply concave with a median process rather more prominent than the outer.

Length: 12 mm. in one specimen, average about 8 mm.

E. pocillimanus is apparently very common; it was represented in the collection by upwards of 30 specimens, some of which were found in dead coral from Castle Harbor, in corallines from Bailey Bay at low water, and from Harrington Sound. The species has been previously recorded from the Mediterranean, and the coast of New Jersey, Long Island Sound, and Vineyard Sound.

***Gammarus breweri* sp. nov.**

Eyes large, compound, subtriangular, situated well forward on interantennal lobes.

First antennae more than half as long as body with peduncle about as long as flagellum; second joint of peduncle slightly longer than first but more slender; third joint very short and scarcely to be distinguished from first segments of flagellum, which is composed of about 17 segments gradually diminishing in length toward apex; accessory flagellum of moderate size made up of 6 joints. Second antennae shorter than first, gland cone very slender and long, reaching nearly to apex of third segment, which is stout, about twice as long as broad; fourth and fifth segments long and slender, fifth slightly longer than fourth; whole peduncle longer than that of first antennae; flagellum not as long as last 2 joints of peduncle, made up of about 8 gradually diminishing segments.

Mandibles with all parts well developed; palp 3-jointed with first of moderate size, broader apically and produced on inner margin to form triangular process distally, third joint about $\frac{1}{2}$ as long as second, provided apically with several very long setae; principal cutting edge denticulated, secondary cutting edge made up of about 6 slender teeth; 6 spines in spine row; molar tubercle rather large.

First maxillae with 2-jointed palp, of which the proximal one is slightly longer than broad and the distal one is more than twice as long as broad with a blunt apex bearing numerous setae; outer plate rather long and slender and somewhat curved with numerous branched and forked spines on distal margin; inner plate triangular with fine pinnate spines on inner margin and apex. Second maxillae with plates of nearly equal size, inner one slightly broader than outer which is the longer of the 2, plates rounded apically and provided with setae. Maxillipeds with 4-jointed palp, first joint short, second moderately long, extending beyond apex of outer plate, with setae on inner margin; third joint about twice as long as wide and

broader distally than at base, inner margin and apex with many long setae, fourth joint conical, armed apically with single sharp unguiform spine; outer plate moderately broad, rounded at apex and on outer margin, inner margin provided with broad toothlike spines which become longer toward distal end of plate where they gradually become long setae; inner plate extending hardly to middle of second joint of palp, with distal margin transverse and provided with row of pinnate spines.

In female, first gnathopods with epimeron slightly higher than long, produced anteriorly and ventrally to rather acute angle; second

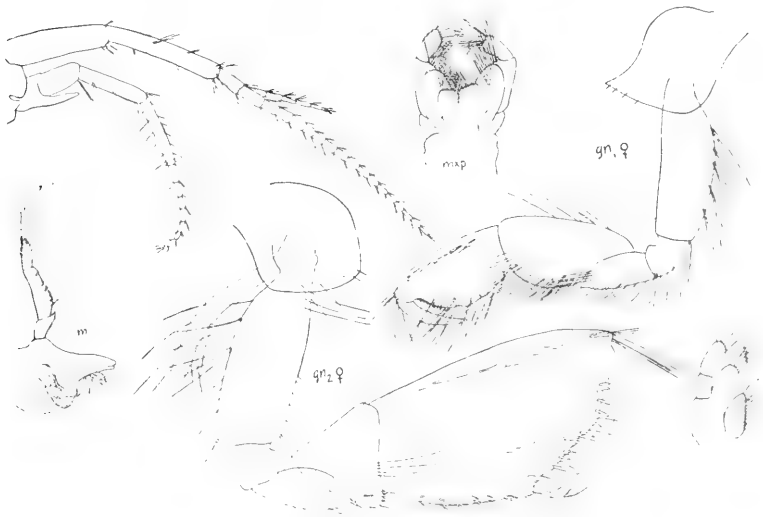


Fig. 22. *Gammarus breweri* sp. nov.

joint moderately long and stout, provided on posterior margin with numerous setae; third and fourth joints of usual form and size; wrist large, with anterior and posterior margins slightly convex and about twice as long as broad, with several long setae on anterior margin and numerous fascicles of setae on posterior margin which forms an even curve with distal margin; hand oval, smaller than wrist, palm rather oblique and provided with short setae and several fascicles of long ones, posterior margin and apex with fascicles of setae; finger rather large, of usual form with several cilia on concave margin.

Second gnathopods much larger and stronger than first; epimeron rhomboidal, about as long as high; second joint fairly stout with long slender setae on posterior margin and short ones on anterior;

third joint broader than long; fourth rectangular, about twice as long as broad with posterior margin prolonged to form slender triangular process; wrist triangular, about as broad as long with several fascicles of setae on posterior margin and several very long setae on distal margin, scarcely as broad as hand which is oval and broader distally than proximally and about twice as long as greatest breadth, palm coarsely dentate, rather oblique and about as long as posterior margin into which it passes by a small triangular process and in which region it is furnished with 5 prehensile spines, rest of palm provided with stout odontoid spines and a few slender setae, posterior margin provided with 7 fascicles of setae, anterior submargin with several more fascicles, apex with fascicle of rather long setae; finger of usual form, rather large.

Pereiopods with epimera of moderate size and with dactyls of usual type, last 3 pairs stouter than first 2, fourth and fifth of nearly equal size.

Posterior margins of first 3 abdominal segments serrated and provided with short setae, posterior margin of third segment with a rounded notch close to postero-lateral angle which thus is rendered very acute.

Third uropods and telson were missing in the single specimen at hand; first and second uropods biramous, with rami subequal, peduncle of first extending as far posteriorly as peduncle of second but rami slightly farther than those of second, peduncle of first slightly longer than rami.

Length of single female exclusive of last abdominal segment and telson 8 mm.

Insula gen. nov.

Body compressed, epimera moderate.

Antennae short, with few segments in flagella, first antennae nearly as long as second and with no accessory flagellum.

Mandibles with denticulate cutting edge and very large molar tubercle, no palp. First maxillae with inner plate provided with 2 terminal setae and with small, one-jointed palp. Second maxillae normal. Maxillipeds with inner plates armed apically with 3 acute processes, outer plate small, palp 3-jointed, stout.

Gnathopods subchelate and equal. Pereiopods normal, no spinning glands; last pair not differing markedly from preceding.

Uropods 3 pairs, terminal pair small and uniramous. Telson small, thick, entire.

This genus resembles *Orchestia* but is markedly different in the greater relative length of the first antennae.

***Insula antennulella* sp. nov.**

Eyes compound, situated close to anterior margin of head, deeply pigmented; lateral lobes of head not developed.

First antennae about $\frac{1}{4}$ as long as body; peduncle short and scarcely to be differentiated from flagellum, first joint broader than long, second about as long as broad and narrower than first, third joint as long as second, about $\frac{2}{3}$ as broad as second and scarcely differing from joints of flagellum which number 4. Second antennae longer than first and stouter, peduncle longer than flagellum, third joint stout and slightly longer than wide, fourth joint more slender

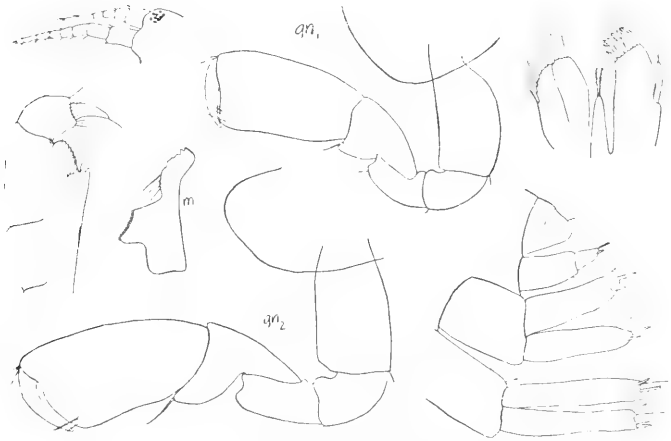


Fig. 22. *Insula antennulella* sp. nov.

than third, fifth joint small, slightly shorter than preceding and very similar to first joint of flagellum which is made up of 5 joints.

Mandibles moderately stout, with principal cutting edge divided into 5 teeth and with secondary cutting edge short, deeply incised, molar tubercle very large and cylindrical, palp absent. Lower lip without inner plates and with outer plates broad, mandibular processes short and not prominent. First maxillae with inner plate slender, triangular, with 2 setae apically, outer plate large, armed with pectinate setae on oblique distal margin; palp weak, 1-jointed, not extending as far as outer plate. Second maxillae of usual form with narrow plates provided with setae on apex. Maxillipeds with inner plates narrow and long, with distal margin produced to form 3 triangular teeth and provided with a few setae; outer plate slightly longer than inner and with rounded apex, provided with setae; palp

strong, 3-jointed, first joint cylindrical, twice as long as wide, with a few setae on distal inner angle, second joint short, about as long as broad, with long setae on apical border, third joint conical, about as long as preceding, provided apically with a single seta.

First gnathopods of male with epimeron rather short, produced anteriorly to form rounded angle; second joint stout, third joint short; fourth joint about twice as long as broad; wrist cup-shaped, articulating with anterior margin of fourth joint, slightly longer than broad, distally expanded to width greater than that of proximal end of hand, posterior margin bearing a single, stout seta distally; hand subchelate, nearly twice as long as wide, subrectangular, slightly broader distally, palm transverse, slightly irregular in form; finger of usual form and as long as palm. Second gnathopods very similar in form to first but slightly larger; wrist with more prominent posterior lobe than that of first; palm convex.

Epimera moderate, with ventral margins rounded; pereopods of normal form, furnished with clawlike fingers and with no spinning glands.

Uropods, 3 pairs, of which the first pair is the longest, with 2 rami of lanceolate form, armed distally with several stout spines; second pair also biramous but much shorter than first; third pair very short, uniramous, with ramus much shorter than peduncle.

Telson small, thick, entire, with few short setae at apex.

Length about 2 mm.

The genus was represented by a single male specimen taken from the surface in the evening, May, 1898.

***Orchestia platensis* Kröyer, 1845.**

1845. Kröyer, *Naturhistorisk Tidsskrift*; ser. 2, vol. 1, p. 304, pl. 2, fig. 2.

Eyes compound, made up of many small ocelli, moderate, circular.

First antennae very short, extending not quite as far as tip of penultimate joint of peduncle of second antennae; segments of peduncle subequal in length; flagellum very short, $\frac{2}{3}$ as long as peduncle, made up of several joints terminating in several short setae. Second antennae of moderate length; first and second fused with head; third joint shorter than broad; fourth joint slightly more than twice as long as broad; fifth joint considerably longer than fourth and more slender; flagellum about as long as peduncle, each segment provided with several setae at distal end.

Mandibles elongated, cutting edges divided into several teeth, spines on spine row well developed; molar tubercle large; palp

wanting. First maxillae with inner plate moderately long and slender, provided apically with 2 plumose spines; outer plates somewhat longer than inner, furnished with forked and branching spines apically; palp very small, being represented by small spine on outer margin of outer plate. Maxillipeds with small inner plate which reaches scarcely as far as distal end of first joint of palp and is provided with 3 toothlike spines alternating with plumose spines on apical margin; outer plate about as wide as inner but reaching

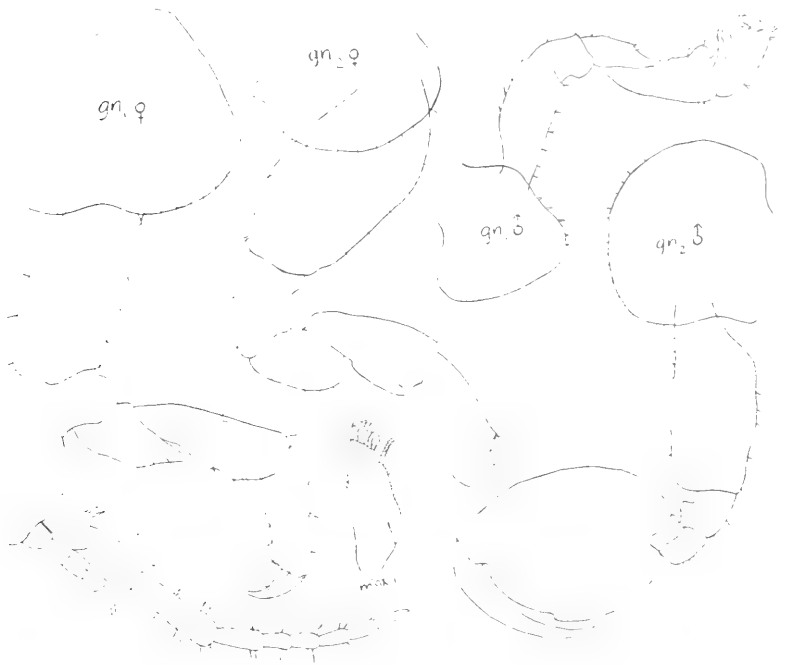


Fig. 24. *Orchestia platensis* Kröyer.

nearly to extremity of second joint of palp, rounded apically and provided with numerous stout setae on inner margin and apex; palp 3-jointed, stout, first joint not as long as wide, becoming broader distally, second joint also broader than long and furnished with a lobe on inner margin which is provided with setae similar to those of outer plate and extending beyond proximal margin of last joint which is rounded apically and slightly longer than wide, bearing apically several short setae.

In female, first gnathopods smaller than second: with subtriangular epimeron having ventral margin slightly indented by broad notch;

second joint moderately stout with a few setae on anterior and posterior margins; third joint shorter than broad; fourth joint triangular, twice as long as broad with articulation with wrist near proximal end of anterior margin, posterior margin provided with a few setae; wrist triangular, nearly three times as long as broad, wider than hand, provided scantily with setae; hand not as long as wrist nor as broad, subrectangular, furnished with fascicles of spines on anterior and posterior margins, palm very short and nearly transverse; finger of usual form and size with circlet of short setae about $\frac{2}{3}$ distance to apex.

Second gnathopods with rounded epimeron bearing subtriangular process posteriorly; second joint very stout with anterior margin strongly convex and provided with setae; third joint longer than broad with anterior margin slightly concave and posterior margin convex; fourth joint shorter than third but scarcely as broad; wrist articulating with nearly entire anterior margin of fourth joint, triangular, twice as long as broad, distal margin transverse; hand somewhat elongate, oval, with rounded apex, anterior margin notched near apex to receive short finger, posterior margin rounded, longer than anterior margin so that hand is weakly chelate, palm short, slightly concave, provided with setae; finger rather small and curved, not reaching as far distally as hand.

In male, first gnathopods with trapezoidal epimeron in which the ventral margin is nearly twice as long as dorsal, posteriorly elongated to form a semicircular lobe of moderate size, anterior margin provided with many short sharp spines; second joint moderately long; much broader at distal end than at proximal, provided with setae on anterior and posterior margins; third joint about as broad as long; fourth joint similar to that of female, twice as long as broad, having articulation with wrist by means of oblique portion of anterior margin; wrist very long, triangular, having rounded lobe on distal part of posterior margin provided with numerous spines of various sizes; hand more or less rectangular with distal margin considerably longer than proximal and at right angles to anterior margin, posterior margin strongly convex toward distal end, palm moderately long, passing by even curve into posterior margin, which region is minutely spinulose, palm very finely serrate and provided with numerous submarginal setae; finger moderately long, not greatly curved, provided with encircling row of setae near middle.

Second gnathopods with semicircular epimeron slightly longer than high, with numerous short setae on ventral margin; second joint moderately stout, very slender at proximal end; third joint

longer than broad with triangular process on anterior margin; fourth joint subrectangular, articulating with wrist by entire anterior margin; wrist scarcely $\frac{1}{2}$ as long as wide, broader at distal end, articulating by anterior wall of V-shaped notch in posterior margin of hand which is large and oval and nearly twice as long as broad, palm strongly convex, nearly as long as posterior margin and separated from latter by broad shallow notch, provided with numerous stout submarginal spines; finger very long, extending beyond palm, curved and pointed.

Pereiopods with moderate epimera; appendages devoid of spinning glands and provided with dactyls of usual form; second joint of last pereiopods with posterior margin serrate.

Abdominal segments with postero-lateral margins of anterior 3 serrated.

Uropods, 3 pairs, of which the last pair are uniramous; rami of first pair subequal and not as long as peduncle, provided with sharp spines; second uropods not extending as far as first, rami subequal and about as long as peduncle; terminal uropods short, ramus rather slender, not as long as peduncle which is slightly conical and stout.

Telson emarginate, subtriangular, rather thick, not extending as far as peduncle of last uropods, provided with 2 setae on dorsal side of apex and near middle.

Length 11–12 mm.

This is one of the commonest known species of Amphipod, being found on the sea shore of nearly all climates. It has been recorded from the Rio de la Plata, the Atlantic coast of North America from the Bay of Fundy to New Jersey, the Mediterranean, and the Sea of Tiberias. The species occurs in abundance under decaying seaweeds at high water mark on all the shores of Bermuda. Prof. Verrill obtained large numbers by attracting them to a pan of alcohol placed on the beach in the night by means of a lantern.

Hyale prevostii (Milne Edwards, 1830) Stebbing, 1888.

1830. *Amphithoe prevostii*. Milne-Edwards, Annales Sc. Nat. (1) vol. 20, p. 378.

1888. *Hyale prevostii*. Stebbing, Rept. of Challenger, vol. 29, p. 144.

Eyes compound, well separated from each other dorsally, oval in form, deeply pigmented.

First antennae terminating about on level with first third of flagellum of second antennae; peduncle slightly less than $\frac{1}{2}$ as long as flagellum, first joint longest and stoutest, third slightly shorter than second which in turn is about $\frac{1}{2}$ as long as first; flagellum composed of about 12 elongated segments. Second antennae not as long as body, with peduncle less than $\frac{1}{2}$ as long as flagellum; third joint scarcely as broad as long, fourth and fifth joints subequal in length, fourth much thicker than fifth; flagellum composed of about 16 elongated segments.

Mandibles strong, oblong, principal and secondary cutting edges divided into 3 or 4 teeth of different sizes, molar tubercle very



Fig. 25. *Hyale pectinii* (Milne-Edwards).

large and cylindrical with flat grinding surface, palp absent. Lower lip with no inner plates, outer plates stout, rather widely separated from each other, anterior margins rather short and densely ciliated, mandibular processes short but strong. First maxillae with 1-jointed palp which does not extend beyond apex of outer plate, provided with single apical seta; outer plate large, having oblique apical margin with numerous stout, forked and pectinate spine teeth; inner plate slender, triangular, with 2 plumose spines at apex. Second maxillae with inner plate rather shorter than outer and about as wide, both plates provided with setae apically. Maxillipeds with 4-jointed palp; inner plates rectangular extending nearly as far as apex of first joint of palp and provided on distal margin, which is transverse, with 3 triangular odontoid spines and numerous plumose spines which also occur on the straight inner margin; outer plate

extending slightly beyond apex of first joint of palp, outer margin convex and apical margin rounded and provided with numerous submarginal setae; palps strong, first joint with outer margin about 3 times as long as inner, second joint nearly twice as long as first and very broad on account of presence of broad lobe on inner side which is produced distally and bears numerous long, stout setae at apex and distal part of inner margin; third joint about as long as first, provided with broad, rounded lobe on inner side at distal end so that joint is much broader distally than proximally, outer apex also provided with small, rounded lobe, distal margin and lobes armed with many long, stout setae; fourth joint about as long as third, clawlike, with concave margin provided with numerous setae.

In female, first gnathopods somewhat smaller than second; epimeron rather deeper than long with anterior ventral angle rounded and not greatly produced; second joint moderately stout, with anterior margin slightly concave, posterior margin convex and proximal end much thinner than distal, anterior distal angle produced to form rounded lobe, posterior margin with 2 rather stout pectinate spines near middle; third joint short, with posterior distal angle provided with long pectinate spine and several setae; fourth joint subrectangular, more than twice as long as broad, provided with several pectinate spines on distal margin; wrist $\frac{2}{3}$ as broad as long, articulating with fourth joint by entire anterior margin of fourth, posterior margin forming a semicircular lobe which is provided with closely set row of pectinate spines; hand subrectangular, slightly broader at distal end than proximal, posterior margin provided with row of pectinate spines occupying middle third of margin which at this point is slightly convex, outer surface of hand provided with diagonal row of stout, plumose spines, palm slightly oblique and convex, provided with several setae and 2 prehensile spines; finger of usual form, short and stout and provided with several setae on concave margin.

Second gnathopods similar to first but having epimeron subrectangular with ventral margin rounded and palm of hand slightly more oblique than that of first; whole appendage stouter in all respects than first.

In male, first gnathopods with epimeron having anterior ventral angle not greatly produced; second joint stout, with anterior margin straight and posterior margin convex with several sharply pointed spines at nearly equal distances from each other; third joint about as long as wide; fourth subrectangular with anterior margin forming articulation with wrist which is triangular, much longer than wide

and with posterior margin produced to form prominent semicircular lobe which is provided with row of stout, pectinate spines; hand suboval, slightly longer than wrist, posterior margin with single stout toothlike spine situated submarginally; palm rather oblique and slightly convex, provided with a regular row of submarginal setae and a very large prehensile spine; finger of usual form, moderately stout.

Second gnathopods with rounded epimeron, about as high as long; second joint rather short with anterior margin prolonged distally to form triangular process; third joint short; fourth joint quadrilateral, posterior margin much longer than anterior, distal margin rather longer than proximal; wrist articulating with anterior margin of fourth and having form of equilateral triangle; hand oval, with base incised to form 2 equal lobes, the anterior one of which forms articulation with wrist, about twice as long as wide, palm rather longer than posterior margin which is separated from it by several prehensile spines and distinct prehensile angle, provided with double row of rather stout submarginal setae; finger rather long and curved in usual way.

Fourth epimeron much higher than fifth which is suboval. Fifth and sixth pereopods with sixth joint having spine and setae on posterior margin.

Uropods essentially as in *H. pontica*; telson semicircular, broader than long and divided by deep incision nearly to base.

Length 7–9 mm.

The species, which is apparently one of the commonest species in Bermuda, occurs very abundantly among the fronds of *Ulva* in the Mediterranean and is reported from the east coast of North America, Rio Janeiro, and Valparaizo, Peru.

Some of the specimens were collected on Somerset Island by W. M. Rankin in 1898, there were some also collected from dead coral from Castle Harbor.

***Hyalé pontica* Rathke, 1837.**

1837. Rathke, Mém. Acad. Impér. des Sci. de St. Pétersbourg, vol. 3, p. 378, pl. 5, fig. 20–28.

Eyes large, compound, subtriangular, ocelli small and arranged close together.

First antennae about $\frac{1}{3}$ as long as body, extending as far as middle of second antennae; peduncle short, more than $\frac{1}{3}$ length of entire appendage; first joint fairly stout, about twice as long as wide with a few setae around distal margin; second joint more

slender and not so long as first; third more slender than second and slightly shorter; flagellum with 13 segments. Second antennae with flagellum much longer than peduncle, fourth segment about $\frac{1}{3}$ shorter than fifth; first, second, and third joints short and provided on distal ends with setae; flagellum made up of about 20 segments provided with setae on distal ends.

Mandibles strong, palp wanting; both cutting edges divided into 5 or 6 teeth; 5 plumose spines on spine row; molar tubercle large;

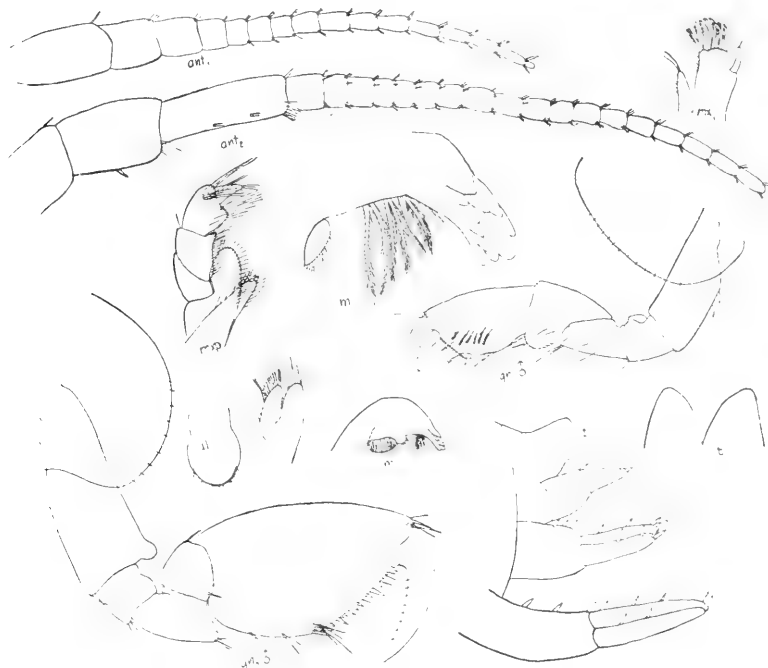


Fig. 26. *Hyale pontica* H. Rathke.

bearing plumose flagellum. Lower lip with no inner plate; outer plate broad, with anterior margin entire and mandibular processes rather small. First maxillae with inner plate slender, triangular and furnished with 2 plumose spines apically; outer plate moderately large with 9 stout pectinate spines in a double row on distal margin which is transverse; palp small and slender, one-jointed, furnished with setae at apex. Second maxillae with inner plate somewhat smaller than outer; both oval in form; inner plate provided with pectinate spines on apex and distal half of inner margin; outer plate with

numerous setae on apex, and several small setae on inner margin. Maxillipeds with 4-jointed palp, the fourth joint of which is conical and provided with a fascicle of fine setae on apex; third joint very broad, narrower at base than at apex, with many long setae near distal margin; second joint about as long as third, with rounded process on distal end of inner margin which is provided with setae; first joint short, with outer margin much longer than inner; outer plate reaching nearly to distal end of second joint of palp, provided with setae on rounded apex and inner margin; inner plate long and narrow, with fine setae on outer and inner margins and several toothlike spines on apex.

In male, first gnathopods smaller than second, with epimeron elongated anteriorly and having ventral margin only slightly convex and provided with many submarginal setae; second joint projecting half its length beyond epimeron, constricted proximally, provided with 2 stout curved spines on posterior margin; third joint as broad as long; fourth joint about twice as long as wide, articulating with wrist by anterior margin; wrist triangular, having rounded lobe on posterior side which is provided with many setae; hand subrectangular, not so broad as wrist and having palm slightly oblique, provided with diagonal row of plumose spines across surface and with group of setae $\frac{2}{3}$ distance to distal end of posterior margin, palm provided with many submarginal setae of various lengths and with prehensile spine; finger strong, curved, and provided with a few setae on inner margin.

Second gnathopods with epimeron rounded ventrally, higher than long and bearing triangular lobe on posterior margin and submarginal setae ventrally; second joint extending considerably beyond epimeron, with rounded lobe at antero-distal angle; third and fourth segments essentially as in first gnathopod; wrist triangular and smaller than in first; hand large, oval, about twice as long as broad, posterior margin continuous with palm by even curve and provided with many teeth and setae of various lengths, prehensile spine present; finger strong and curved, having a few setae on concave margin.

Pereiopods furnished with dactyls, last 2 pairs subequal; epimera moderate with margins entire except for rounded notch on first 3; that of second pereopod largest of series.

Uropods, 3 pairs; first and second biramous, first longer than second and third, with rami somewhat shorter than peduncle, the inner one of which is slightly longer than the outer, provided with 2 or 3 spines on dorsal margin and several on apex; second with peduncle relatively shorter than that of first, otherwise of similar

form; terminal uropods quite short, uniramous, with ramus shorter than peduncle and bearing several spines on apex, peduncle extending beyond telson.

Telson thick, very deeply cleft, broader than long.

There were present in the collection only a few males having a length of about 15 μ m.

The species has been previously recorded from the North Atlantic, the North Sea, and the Mediterranean.

***Hyale trifoliadens* sp. nov.**

Eyes small, compound, deeply pigmented in alcoholic specimens.

First antennae with peduncle half as long as flagellum; first joint slightly longer than second, stout, scarcely twice as long as broad; third joint short and slender, very similar to first joint of flagellum which is made up of about 9 segments. Second antennae much



Fig. 27. *Hyale trifoliadens* sp. nov.

longer than first, scarcely $\frac{1}{2}$ as long as body; peduncle nearly as long as entire first antennae; first and second joints short and broad with gland cone slender; third joint not as long as broad; fourth joint twice as long as broad and shorter than fifth which is more slender; flagellum made up of about 15 segments provided with setae on distal margins.

Mandibles strong; palp wanting; principal cutting edge divided into 3 teeth; secondary cutting edge with 2 processes, much smaller than principal; spine row with a number of short plumose spines; molar tubercle large, furnished with a plumose seta.

Lower lip and first and second maxillae as in *H. pontica*. Maxillipeds with inner plates well developed, narrow, extending as far as first joint of palp, provided with plumose spines on inner margin and apex which also bears 3 odontoid spines; outer plate extending well beyond inner and bearing 2 plumose spines apically and many setae on inner margin; palp well developed with second joint subrectangular and bearing a semicircular lobe on inner distal angle and with many setae on inner margin; third joint about as long as first, broader distally than proximally and bearing many setae on distal margin; fourth joint more or less clawlike, not as long as preceding joint.

In male first gnathopods with epimeron longer than high, rounded ventrally but with anterior angle projecting well forward; second joint moderately stout, projecting well beyond epimeron, bearing on anterior margin 2 or 3 short setae and several long setae on distal posterior angle; third joint about as long as broad with a few setae on distal posterior angle; fourth joint about twice as long as wide with a few setae on posterior distal angle; fifth joint articulating with fourth along nearly entire anterior margin, more or less triangular with prominent semicircular lobe bearing long setae on posterior margin, anterior margin moderately convex; hand subrectangular, rather more than twice as long as broad, not as broad as wrist, posterior margin bearing single fascicle of setae near middle, palm transverse and furnished with setae, the longest of which are at the prehensile angle; finger fairly stout, of usual form.

Second gnathopods with epimeron slightly shorter than that of first gnathopods with ventral margin evenly rounded; second joint robust but slender at proximal end, bearing a few setae on anterior and posterior margins; third joint as long as broad, with a few setae on distal posterior angle; fourth joint triangular, articulating with wrist by distal portion of anterior margin, bearing several setae on apex; wrist rather short, bearing long curved process on posterior side which renders wrist broader than hand which bears a fascicle of setae apically; hand oval, rather broader distally than proximally, about twice as long as broad, palm somewhat oblique, straight, provided with numerous setae of various lengths and prehensile spine, posterior margin with fascicle of setae near middle; finger of usual form and size; second gnathopods in every way stronger than first.

In female, first gnathopods with wrist longer than in male and provided with many more setae on posterior margin; hand shorter than in male and furnished with many setae on posterior margin,

provided with prehensile spine. In second gnathopods, wrist shorter than in first and hand more nearly oval with palm quite oblique and posterior margin much shorter than palm and provided with several groups of spines, palm with numerous submarginal spines of various lengths and 2 prehensile spines; finger moderately stout, provided with 2 short cilia on inner concave margin.

Other characters as in *H. pontica*.

The species was represented by several individuals 6–8 mm. in length.

Parhyalella gen. nov.

First antennae longer than peduncle of second; first maxillae with palp wanting; maxillipeds with 4-jointed palp, last joint being unguiform; gnathopods subchelate; telson entire.

This genus is closely related to *Hyaella* but differs from it in the absence of a maxillary palp.

Parhyalella batesoni sp. nov.

Eyes moderately large, compound, situated well toward dorsal side of head.

First antennae nearly as long as second; peduncle longer than flagellum which is composed of about a dozen rather short segments which are markedly broader at the distal than at proximal end; first joint of peduncle very stout, scarcely longer than broad, second joint subequal in length but much narrower, third joint shorter than second and about twice as long as broad. Second antennae with first and second joints of peduncle short and coalesced with head, gland cone absent, third joint about as broad as long, fourth joint rather more than twice as long as broad, fifth joint somewhat longer and more slender than fourth; flagellum very short, scarcely longer than last joint of peduncle, made up of only a few segments which rapidly become shorter and thinner distally.

Mandibles with principal cutting edge divided into 6 teeth of which the second and third from the anterior end are largest, secondary edge divided into 5 nearly equal teeth, molar tubercle very strong, palp wanting. First maxillae with palp wanting, outer plate rather large with pectinate and branched spine-teeth on distal end; inner plate rather short and slender with 2 plumose spines on apex. Second maxillae with outer and inner plates rather narrow and subequal, outer one with setae on distal margin, inner one with setae also on distal half of inner margin. Maxillipeds with inner and outer plates rather small, outer plates extending as far as apex of first

joint of palp and inner one extending not quite so far; distal margin of inner plate provided with 3 odontoid spines and numerous plumose spines, outer plates with inner margin and apex which is rounded, provided with setae; palp 4-jointed with first joint very short and outer apex rather prolonged, second joint not as long as broad with broad lobe extending along inner side provided with row of stout spines, fourth joint clawlike, about as long as third joint.

In male, first gnathopods with moderately high epimeron produced at antero-ventral angle; second joint stout; wrist triangular, about

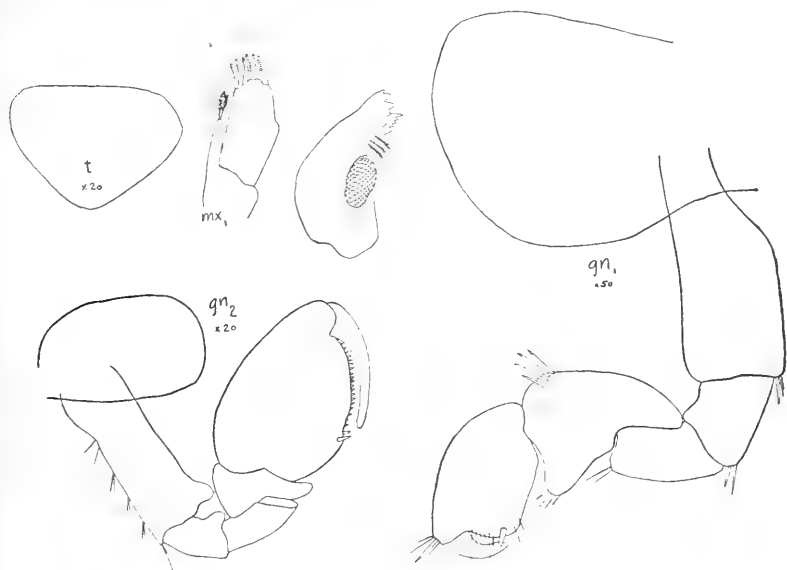


Fig. 28. *Parhyalella batesoni* sp. nov.

as broad as long and bearing prominent rounded lobe on posterior margin; hand subrectangular, not as broad as wrist, nearly twice as long as wide, palm rather short and nearly transverse, provided with setae of various lengths, prehensile angle rounded and furnished with stout spine; finger short and very stout.

Second gnathopods very large with subrectangular epimeron which are higher than long; second joint of moderate proportions with projecting lobe on anterior side; fourth joint with anterior and posterior margins nearly parallel and with posterior apex somewhat produced; wrist triangular, short, with very broad lobe from distal posterior angle which projects as far as posterior margin of fourth joint; hand oval, about twice as long as wide, with base deeply

incised, palm oblique and furnished with submarginal setae, prehensile angle moderately prominent and bearing two stout setae; finger long and curved.

Telson triangular, about as broad as long with apex rounded.

Length 9 mm. There was a single specimen in the collection.

Microdeutopus anomalus (Rathke, 1843) Bate, 1862.

1843. *Gammarus anomalus*. Rathke, Nova Acta Acad. Caesareo Leopold. Carol. German., vol. 30 I, p. 63, pl. 4, fig. 7.

1862. *Microdeutopus anomalus*. Bate, Cat. Brit. Mus., p. 164, pl. 30, fig. 3.

Eyes small, round, compound, widely separated from each other dorsally, and very close to margin of interantennal lobes. Head produced to form short, rather acutely pointed rostrum.

First antennae about one half as long as body and with principal flagellum longer than peduncle, made up of about 25 segments and provided with accessory flagellum of 4 or 5 elongated joints; second joint of peduncle longest, third joint not more than one half as long as first. Second antennae somewhat shorter than first, with very short flagellum of about 8 joints furnished with setae; glandular cone long and slender; third joint less than twice as long as broad, fourth and fifth joints very long and slender, subequal in length.

Mandibles with all parts well developed, palp 3-jointed, with third joint longer than second and with proximal half broad and distal half tapering to a point and provided on inner margin with setae; primary and secondary cutting edges denticulated. Lower lip with outer plates having anterior margin entire and widely separated from each other and with inner plates wide, mandibular processes long and slender. First maxillae with inner plate small, triangular, provided apically with single plumose spine, outer plate of moderate size with oblique distal margin armed in usual way; palp well developed, 2-jointed, second joint curved and moderately long, with apex rounded and furnished with group of setae. Second maxillae with plates moderately broad and rounded apically, furnished with abundant setae on distal end; outer plate slightly longer and broader than inner. Maxillipeds with large rectangular inner plates extending as far as apex of first joint of palp, and furnished with slender spines apically; outer plates broad, extending nearly as far as apex of second joint of palp, outer margin and apex rounded, inner margin straight and furnished with short odontoid spines which become longer at apex; palp 4-jointed and slender, second joint longest, terminal joint provided with clawlike spine.

First gnathopods of female larger than second; epimeron moderate, third and fourth joints small; wrist rather large, nearly oval in form, about twice as long as broad, posterior margin more convex than anterior and provided with slender setae; hand subrectangular, more than twice as long as broad and somewhat longer than wrist, broader at distal end than at proximal, palm slightly oblique, irregular in shape, with stout spine tooth separating it from posterior margin; finger moderate in size, of usual form with concave margin serrated. Second gnathopods with small rounded epimera as long as high; second joint long and slender, of uniform thickness; third and



Fig. 29. *Microdentopus anomalus* (H. Rathke).

fourth joints small; wrist triangular, twice as long as broad, provided with numerous long setae on posterior margin; hand subrectangular, shorter than wrist, palm nearly transverse, posterior margin and palm provided with abundant setae; finger similar to that of first gnathopod. Marsupial plates oval, about two and a half times as long as broad.

Pereiopods of middle group short, with epimera of moderate size, longer than high; posterior pereiopods very long and slender with second joints moderately expanded.

Uropods, 3 pairs, biramous, first pair extending slightly beyond other two; rami styliform with stout spines at apex and along inner margin, inner rami of first and second longer than outer, inner rami of third uropods slightly shorter.

Telson oval, longer than broad, apex truncated, furnished with 2 symmetrical fascicles of moderately stout spines.

Length, 8 mm. A single female represented the species in the collection.

The species has been previously reported from the Atlantic Coast of Norway, the Shetlands, and the Black Sea.

Autonoe longipes (Liljeborg, 1852) Bruzelius, 1859.

1852. *Gammarus longipes*. Liljeborg, Öfversigt af Kongl. Vetens.-Akad. Forhandl. Stockholm, p. 10.

1859. *Autonoe longipes*. Bruzelius, Skandinavian Amphipoda Gammar., Kongl. Sv. Vetens.-Akad. Handl., vol. 3, p. 28.

Eyes moderate, compound, reniform, approaching very close together on dorsal side of head.

First antennae rather long and slender with long flagellum composed of more than a dozen rather elongated segments; peduncle with first joint rather stout, nearly as long as head, second joint slender and longer than first, third joint small, about $\frac{1}{3}$ as long as second; accessory flagellum made up of 5 joints. Second antennae with peduncle much longer than that of first; gland cone prominent, third joint longer than broad, fourth and fifth joints subequal in length; flagellum about as long as last joint of peduncle, composed of about 5 joints.

Mandibles with principal cutting edge divided into several teeth; secondary cutting edge also denticulate and rather narrow; 4 spines on spine row; palp 3-jointed with third joint longest, about as long as first and second together, inner margin straight, outer margin convex, provided with plumose spines on both margins, second joint about twice as long as first and somewhat stouter, with several long setae on inner margin, first joint rather short, broader at distal end than at proximal. Lower lip with outer plates rounded, anterior margins entire, not very broad; mandibular processes long and pointed, diverging considerably; inner plates broad, rounded. First maxillae with inner plates rudimentary and bearing single long plumose spine apically; outer plates broad, with distal margin oblique, inclining toward inner margin, furnished with usual spine teeth; palp 2-jointed, first joint as broad as long and with single seta on outer distal margin, second joint 4 times as long as broad with blunt apex provided with a number of slender teeth and setae. Second maxillae with oval plates which are rather broad; outer plates provided with many long setae distally; inner plates smaller than outer with

plumose spines on inner margin and setae on distal margin and in a row extending obliquely from middle of distal margin to inner margin proximally. Maxillipeds with inner plates short and provided with plumose spines on transverse distal and inner margins; outer plates extending as far as second joint of palp, having outer margin convex and unarmed and inner margin, which is straight, provided with broad toothlike spines which become more slender distally and become plumose spines around distal margin; palps long, 4-jointed, of which the first joint is longer than broad, the second joint 3 times as long as broad with a number of long setae on inner margin;



Fig. 30. *Autonoe longipes* Bruzelius.

third joint about $\frac{2}{3}$ as long as second, being broader at distal end and provided with many long setae; fourth joint as long as third and unguiform.

In male, first gnathopods with small subrectangular epimeron; second joint very stout, $\frac{2}{3}$ as broad as long, widest in middle; third joint very short with several setae on postero-distal angle; fourth joint longer than third and more slender with a few setae on posterior margin; wrist triangular, broader than long, having posterior margin provided with long setae; hand large, oval, with anterior margin rather convex and much longer than posterior which bears several fascicles of long setae, palm oblique, not very long, provided with

deep notch near prehensile angle and provided with numerous setae, apex of hand with fascicle of long setae; finger rather large, of usual form with concave margin provided with numerous cilia.

Second gnathopods much smaller than first, with rhomboidal epimeron about as long as high; second joint moderate in width, fairly long, anterior margin curved, posterior margin rather strongly convex; third and fourth joints as in first gnathopods but third rather more slender; wrist triangular, rather large, longer and broader than hand, provided with very short setae on anterior margin and with several fascicles of setae on posterior margin; hand subrectangular, provided with setae on anterior and posterior margins, palm moderate, with long prehensile spine and fascicle of setae; finger very large with concave margin serrated.

In female, first gnathopods with second joint much more slender than in male; third and fourth joints provided with many more setae which are also longer than in male; wrist longer than in male, and hand more slender, being subrectangular, with palm somewhat oblique and sinuous, provided with prehensile spine and setae of various lengths, posterior margin with many long setae and anterior submargin with several fascicles of slender setae; finger slender, with concave margin serrated.

Second gnathopods smaller than first, with second joint more slender and wrist broader than in male; hand subrectangular, not unlike that of male but setae rather longer.

Epimera moderately low, being longer than high in each case, diminishing slightly in height posteriorly, those of fourth and fifth pereopods being not more than half as high as long and suboval in form; fourth not emarginate posteriorly; third, fourth and fifth pereopods with second joints normally expanded; last pereopods longest, with fourth, fifth and sixth joints especially long and slender; first and second pereopods with spinning glands.

Uropods, 3 pairs, biramous; first pair longest with peduncle somewhat longer than rami which are equal in length and provided with stout spines; second pair extending posteriorly as far as first; terminal pair very short, not extending as far as preceding, rami styliform.

Telson slightly broader than long, with distal margin slightly concave, postero-lateral angle provided with a spine and several longer setae.

Length 5.5 mm.

This species has been previously reported from Naples, the coast of Scandinavia, Great Britain, and Port Jackson, Australia.

Eurystheus lina sp. nov.

Eyes compound, suboval, situated well on lateral aspect of head on prominent interantennal lobes and widely separated from each other.

Antennae subequal; first antennae rather stout with peduncle somewhat longer than flagellum; first joint of peduncle cylindrical



Fig. 31. *Eurystheus lina* sp. nov.

and about 3 times as long as broad, second joint nearly twice as long as first and more slender, third joint somewhat shorter than second, all joints provided with abundant setae, especially on lower margin; principal flagellum made up of about 11 joints, also provided with abundant setae; accessory flagellum made up of 4 or 5 joints. Second antennae with gland cone rather prominent and moderately long; third joint hardly twice as long as wide and with

distal end somewhat wider than proximal and provided with rather long setae on ventral margin; fourth joint rather long and slender, cylindrical; fifth joint shorter than fourth; flagellum about as long as fourth joint of peduncle, made up of 4 or 5 short, stout segments which are provided with setae.

Mandibles triangular, with principal and secondary cutting edges denticulated, with 9 or 10 spines on spine row and with prominent molar tubercle; palp 3-jointed, first joint short and cup-shaped with proximal end very narrow, second joint about 3 times as long as broad, slightly broader distally and with rather long setae on inner margin, third joint slightly shorter than second with rounded apex which is provided with abundant setae. Lower lip with outer plates having anterior margin entire. First maxillae having inner plate triangular and with numerous setae on inner margin; outer plate of usual form with stout spines on oblique apex; palp 2-jointed, of which the first is about as long as wide and the second is somewhat curved and club-shaped with setae on rounded apex. Second maxillae of usual form with plates rounded distally. Maxillipeds with plates well developed and with 4-jointed palp; inner plates rectangular with distal margin provided with abundant setae and a few spines; outer plates extending nearly as far as distal end of second joint of palp, with inner margin straight and armed with broad toothlike spines and abundant setae, outer and distal margins convex, distal margin with long setae; palp with first joint short, hardly as long as broad, second joint cylindrical, 3 times as long as broad and with long and abundant setae on inner margin, third joint $\frac{2}{3}$ as long as second with rounded apex having abundant setae, fourth joint less than $\frac{1}{2}$ as long as third with rounded apex as in third joint.

In male, first gnathopods with moderate epimera having anterior ventral angle only slightly produced and with very short setae on ventral margin; second joint moderate in size, third joint rather shorter than broad; fourth joint broader toward distal end than proximal with posterior margin much longer than anterior and with 4 or 5 fascicles of setae; wrist as long as second joint, subtriangular with distal margin somewhat oblique, posterior margin with 5 or 6 fascicles of setae and with similar number of fascicles along axis of joint; hand suboval, slightly broader than wrist, more than $\frac{2}{3}$ as broad as long, anterior and posterior margins slightly convex, posterior margin passing by even curve into palm which is slightly convex and provided with setae of various lengths, prehensile angle with spine, posterior and anterior margins with numerous fascicles of setae; finger long and moderately slender, serrated.

Second gnathopods very much larger in every way than first, epimeron small, rounded and not higher than long; second joint large and stout with fascicles of setae on both anterior and posterior margins; fourth joint hardly longer than third which is provided with rounded lobe on anterior distal apex; wrist short and triangular, articulating with fourth joint by most of posterior margin, distal part of margin in form of lobe extending over distal end of fourth joint and provided with numerous setae; hand very large, subrectangular, twice as long as broad with posterior margin provided with numerous setae, posterior margin prolonged distally so that prehensile angle is acute and palm is more or less concave; finger very stout, tapering and rounded apically, concave margin provided with a triangular process near base.

Epimera rather low, first 2 pereopods with spinning glands, last pereopod slightly longer than preceding.

Uropods 3 pairs, biramous; posterior pair extending slightly beyond second which in turn extend slightly beyond first; inner rami slightly longer than outer, styliform.

Telson subrectangular, stout, bilobed, with lobes well separated by triangular emargination and armed apically with 2 or 3 stout spines.

Length 6 mm.

The species was represented by 2 specimens which were collected in 1903.

Podocerosia sophia Boeck, 1861.

1861. Boeck, Forh. Skand. Naturf., vol. 8, p. 666.

Eyes compound, reniform, situated very close to front margin of head.

First antennae slightly longer than second, with first 2 joints of peduncle rather stout, cylindrical and equal in length, last joint $\frac{2}{3}$ as long as first; principal flagellum made up of 5 elongated joints, about as long as last 2 joints of peduncle; accessory flagellum short, consisting of 2 unequal joints, the first of which is much longer than the second. Second antennae with second joint rather short but with gland cone rather long and slender; third joint more than twice as long as broad, slightly thicker distally than proximally; fourth and fifth joints subequal, about as long as first joint of first antennae; flagellum made up of 6 joints, somewhat shorter than that of first antennae.

Mandibles with 3-jointed palp and denticulated cutting edge; first joint short; second and third subequal in length, second cylindrical;

third broader at distal end which is rounded and provided with numerous long setae, some of which are plumose; secondary cutting edge long; molar tubercle prominent. Lower lip with outer plates having anterior margin entire. First maxillae with small triangular inner plate and 2-jointed palp, having terminal joint rounded apically and provided with a few setae; outer plate with distal margin obliquely truncate and provided with toothed and branching spines. Second maxillae with inner plate rounded apically with setae on inner margin; outer plate somewhat longer than inner one and provided with long setae apically. Maxillipeds with plates well developed and 4-jointed palp; inner plate rather slender, triangular, provided with fairly stout spines apically; outer plate with rounded apex, furnished with odontoid spines and setae on inner margin and apex; last joint of palp cylindrical, furnished with single stout spine apically.

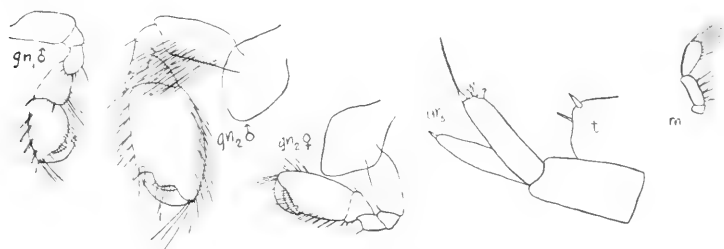


Fig. 32. *Podocerosia sophia* Boeck.

In male, first gnathopods with trapezoidal epimeron projecting well forward, ventral margin provided with short setae; second joint very stout and of moderate length, provided with long setae at distal end of posterior margin; third joint short; fourth somewhat longer than broad and broader at distal end, articulating with wrist by anterior margin; posterior margin and apex provided with long setae; wrist triangular, somewhat longer than broad, with setae on posterior and distal margins; hand oval, somewhat longer than wrist and slightly broader, posterior margin passing by even curve into palm which is convex and provided with submarginal setae and a rather large prehensile spine; hand also furnished with fascicles of setae on anterior margin and apex; finger of usual form, rather long and bearing a single cilium near apex on inner concave margin.

Second gnathopods with subrectangular epimeron much higher than long with ventral margin rounded; second joint stout and

moderately long, anterior margin straight and provided with numerous very long setae; third joint very short; fourth joint small, rectangular, about twice as long as broad with group of setae at apex, articulating with wrist by entire anterior margin; wrist small and cup-shaped, broader than long, with a fascicle of setae on very short free portion of posterior margin; hand large, much larger than that of first, subrectangular, palm rather irregular, convex near articulation of finger, bearing decided cavity with broad bottom in region of prehensile spine, posterior margin prolonged to form triangular process behind which the apex of the finger fits, posterior and anterior margins provided with fascicles of setae, palm provided with a few setae of various lengths; finger rather stout, of usual form.

In female, gnathopods smaller than in male; first gnathopods with relatively longer and more slender finger; second gnathopods with palm regularly convex and lacking prolongation of posterior margin of hand to form triangular process.

Pereiopods of usual form, provided with pointed dactyls, first 2 pairs with spinning glands.

Uropods, 3 pairs, biramous; second pair projecting beyond first and third; terminal uropods having rami nearly as long as peduncle and provided with several stout spines apically.

Telson thick, short, entire.

The species was represented in the collection by a male and a female 2.5 mm. in length, collected by W. G. VanName, 1901. It has been recorded from the Arctic Ocean, Scandinavia, the British coast, and Shetland Isles (70-90 fathoms).

***Isaea longipalpus* sp. nov.**

Eyes small, compound, circular.

First antennae long and slender, more than $\frac{1}{2}$ as long as body, with elongated flagellum; first joint of peduncle stout and armed with stout setae; second joint slender, slightly longer than first; third joint short and narrow, about $\frac{1}{3}$ as long as second; principal flagellum considerably longer than peduncle, composed of numerous elongated joints; accessory flagellum long, made up of at least 4 segments. Second antennae shorter than first; gland cone rather prominent but not long; third joint of peduncle slightly longer than broad; fourth and fifth joints long and subequal in length; flagellum about as long as last joint of peduncle, composed of about 6 joints.

Mandibles strong, triangular, with principal cutting edge denticulated and all parts well developed; palp 3-jointed, the first of which is rather long, only half as broad as long, second joint stouter than

first and about 3 times as long as broad, third joint longest, of tapering form with setae on inner margin and plumose spines on terminal portion of outer margin; secondary cutting edge moderately developed; molar tubercle large and prominent. First maxillae with inner plate rudimentary, bearing a single plumose spine apically; outer plate moderately large, with branching toothlike spines on distal margin; palp 2-jointed, with first joint small, second curved, elongated, larger at distal end, which is rounded, than at proximal end and armed with toothlike spines. Second maxillae of moderate size, plates rounded apically and provided with many setae. Maxillipeds with plates well developed and with palp 4-jointed; inner



Fig. 33. *Isaea longipalpus* sp. nov.

plates moderately large, rectangular, with 3 spine teeth and plumose spines on terminal margin, inner margin with plumose spines; outer plates large, oval, with dagger-shaped spines on distal portion of inner margin and apex; palp rather slender with numerous setae on inner margin of joints; second joint cylindrical, third with enlarged, rounded apex bearing setae, fourth conical and bearing a terminal spine.

First gnathopods larger than second; epimeron irregularly rectangular; second joint rather long and stout, slightly more than twice as long as broad; third joint short; fourth more or less oval with setae on posterior margin; wrist articulating with anterior margin of preceding joint, triangular, somewhat longer than broad with convex posterior margin provided with long setae; hand sub-

rectangular, as broad as wrist and about $1\frac{1}{2}$ times as long, slightly broader distally than proximally, palm irregularly incised, slightly oblique with numerous setae and large prehensile spine, posterior margin with several fascicles of setae; finger of usual form with concave margin serrate, somewhat longer than palm.

Second gnathopods with rather small subrectangular epimeron which is longer than high and with rounded angles; second joint moderate; third joint short; fourth oblong with wrist articulating by whole anterior margin, provided with setae on distal portion of posterior margin and apex; wrist triangular, twice as long as wide and as wide as hand, with many setae on posterior margin; hand subrectangular, about as long as wrist with palm nearly transverse and provided with numerous submarginal setae and a prehensile spine, posterior margin with numerous setae; finger of usual form, fairly stout, serrated on concave margin.

Epimera rather low; gills oval and broad. In the single specimen at hand all the pereopods were missing.

Uropods, 3 pairs, biramous; rami styliform; first and second projecting slightly beyond terminal pair; all provided apically with groups of several stout spines.

Telson thick, entire, about as broad as long, with 2 setae at each distal angle.

Dorsally and laterally the 5 anterior thoracic segments and the head are marked with irregular masses of pigment in the form of a fine network which, in the alcoholic specimen, is brownish black.

Length 2.5 mm.

The single specimen in the collection was found in Bailey Bay in coralline at low water in 1898.

***Amphithoe longimana* Smith, 1874.**

1874. Smith, Rep. U. S. Fish. Com., vol. 1, p. 563.

Eyes small, compound, somewhat oval, made up of many ocelli crowded together.

First antennae longer than second, and nearly as long as body, with no accessory flagellum; first joint of peduncle stout, cylindrical, about 5 times as long as broad, provided with a few setae; second joint somewhat longer than first and more slender; third joint about $\frac{1}{2}$ as long as first and much thinner, bearing a few setae on distal end; flagellum slender, composed of about 32 segments each with short setae on apical margin. Second antennae long and slender; gland cone small and slender; third joint of peduncle nearly twice as long as wide and with a few setae at apex; fourth and fifth joints

subequal and slightly longer than second joint of first antennae; flagellum about as long as peduncle and made up of 12 to 15 segments.

Mandibles with principal cutting edge divided into 7 teeth diminishing regularly in size from apical one which is largest; secondary

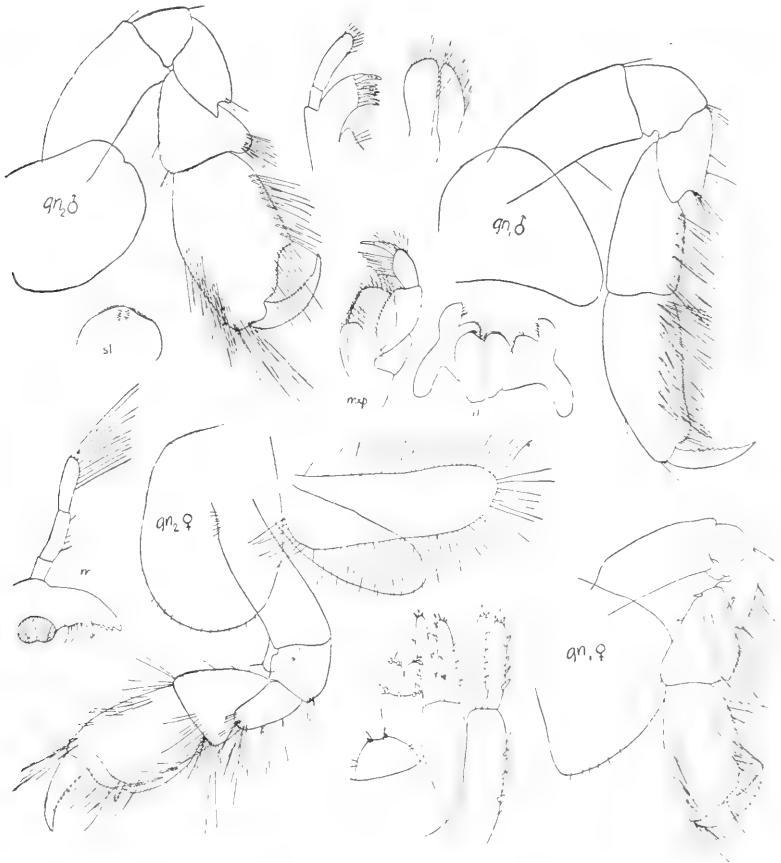


Fig. 34. *Amphithoe longimana* Smith.

cutting edge small and likewise denticulated; spine row with 5 plumose spines; molar tubercle large; palp 3-jointed with first joint short and not much longer than wide, second joint very slightly longer than third and provided with setae on inner margin, third joint rounded apically where joint is thicker than at base, provided with many long setae on apex and distal half of inner margin.

Lower lip with large outer plates incised at apex; mandibular processes large and diverging; inner plates large and oval. First maxillae with small triangular inner plates armed with short setae on inner margin; outer plates large, curved, with distal margin oblique and provided with 8 or 9 branching toothlike spines; palp 2-jointed, first joint $1\frac{1}{2}$ times as long as broad, second joint thicker than proximal and about 4 times as long as broad, rounded at apex which is provided with slender conical spines. Second maxillae with outer plates much broader at distal end than at proximal; inner plate not quite as long as outer, triangular. Maxillipeds with plates well developed; inner plates extending as far as first joint of palp with apex rounded and provided at inner distal angle with 2 stout teeth, external to which are 8 plumose spines; outer plates broad and large, extending as far as second joint of palp, provided on inner margin with teeth which become longer toward apex and pass over into long setae extending around apex to outer side; palp 4-jointed, first joint short, second nearly twice as long as wide with many setae on inner margin; third joint equal to first in length, rounded apically where it is broader than at base, provided with a fascicle of setae on outer distal angle and many setae on inner margin; fourth joint about $\frac{2}{3}$ length of third, slender and curved, bearing a stout spine apically which renders whole segment as long as third.

In female, first gnathopods with epimeron produced anteriorly to acute angle, ventral margin convex and provided with short setae on anterior portion; second joint moderately slender, broader at distal end which bears on anterior margin a semicircular lobe with a short seta; third joint broader than long; fourth joint rather slender, with posterior margin long and convex, bearing several fascicles of setae, anterior margin short, distal end broader than base and cup-shaped; wrist as long as third and fourth joints together, triangular, broader than hand, posterior margin with many long setae, anterior margin with 2 toothlike spines on proximal half, distal margin slightly concave; hand subrectangular, twice as long as broad, somewhat longer than wrist, anterior and posterior submargins with numerous fascicles of setae, palm oblique and convex, provided with many setae and a stout prehensile spine; finger rather long and stout with a few serrations distally on concave margin.

Second gnathopods with oval epimeron having ventral margin armed with setae; second joint with a number of short setae at proximal end of anterior margin; third joint much as in first gnathopod

but with group of setae at posterior distal corner; fourth joint scarcely longer than third, oblong, $\frac{2}{3}$ as broad as long, armed with several fascicles of setae on anterior margin; wrist triangular, not as long as wrist of first gnathopod, provided with numerous setae on distal margin; hand much like that of first gnathopod but broader and shorter, palm less oblique and posterior margin more convex; finger short and stout with concave margin serrate.

First and second pereopods with spinning glands: epimera moderate, gradually increasing in size toward posterior end, with ventral margins in each case rounded and armed with very short setae.

Uropods, 3 pairs, biramous; second pair extending beyond first and third; first pair with outer margin of peduncle armed with 3 conical toothlike spines, inner ramus more than half as long as peduncle and slightly longer and more slender than outer ramus; rami provided with toothlike spines on margins and apically; second pair like first but stouter and with no spines on peduncle; third pair with peduncle extending beyond that of second, armed with several toothlike spines on distal margin; rami very short, about half as long as peduncle and terminating in 2 stout hooked spines and armed with several long setae.

Telson broader than long, semicircular, with apex slightly truncate and with lateral margins slightly produced to form triangular processes which are each armed with a seta, apex also provided with 4 long setae and lateral margins with 4 shorter ones.

Length 12 mm.

The species was represented by a number of specimens. It occurs abundantly on the New England coast.

Amphithoe rubricata (Montagu, 1808) Leach, 1813.

1808. *Cancer rubricatus*. Montagu, Trans. Linn. Soc. London, vol. 9, p. 99; pl. 5, fig. 1.

1813-14. *Amphithoe rubricata*. Leach, Edinb. Encycl., vol. 7, p. 403.

Eyes moderately large, round, compound.

First antennae longer than second. First joint of peduncle fairly stout and shorter than second; third joint short and slender, hardly to be distinguished from proximal joints of flagellum, about $\frac{1}{3}$ as long as second joint; flagellum composed of many segments, long and slender and less than twice as long as peduncle. Second antennae with peduncle longer than that of first; fourth and fifth joints subequal in length; third joint rather broad and shorter than broad; flagellum composed of many segments.

In female, first gnathopods with trapezoidal epimeron projecting anteriorly by acutely rounded angle, ventral margin slightly rounded and armed with numerous short setae; second joint robust, extending well beyond epimeron, anterior margin straight with small flat rounded lobe at distal end; third and fourth joints short, fourth joint triangular, widened distally, provided with setae at apex and on posterior margin; wrist triangular armed with a few rather long stout setae on rounded posterior margin which forms a kind of lobe so that the wrist is broader than the hand, wrist provided with several fascicles of setae on surface; hand rather long, about $\frac{1}{3}$ longer than wrist, subrectangular with anterior and posterior margins nearly parallel, with posterior margin and palm provided with many setae of different lengths, palm oblique and passing evenly into

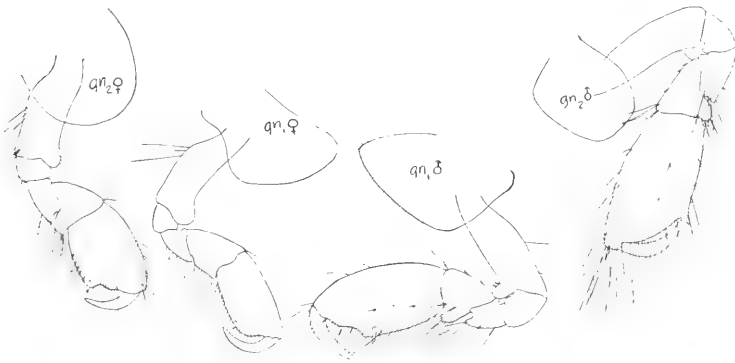


Fig. 35. *Amphithoe rubricata* (Montagu).

posterior margin, prehensile angle with a large submarginal spine; finger very long and slender with inner concave margin serrate.

Second gnathopods with rectangular epimeron nearly as long as high, convex on ventral margin which is armed with many short setae; second joint similar to that of first gnathopod; third joint short; fourth joint twice as long as broad with wrist attached to anterior margin, provided with setae apically and on posterior margin; wrist more or less triangular, posterior margin strongly convex forming a lobe which makes the wrist wider than the hand; hand subrectangular, much shorter and stouter than that of first gnathopod, palm oblique and forming with posterior margin a small process which bears a submarginal prehensile spine, anterior margin provided with 4 fascicles of slender setae, posterior margin and palm

with many setae; finger curved, moderately slender, with concave margin serrated.

In male, first gnathopods with epimeron prolonged anteriorly with antero-ventral angle rounded; second joint fairly stout; fourth joint short with fascicle of setae on acute postero-ventral angle, wrist nearly as long as hand with anterior and posterior margins parallel, the latter of which is provided with numerous fascicles of setae; hand long and slender, almost rectangular, about twice as long as broad and not broader than wrist, anterior margin slightly convex, posterior margin with many setae, palm very short and irregular; finger long and of usual form with concave margin provided with coarse serrations.

Second gnathopods with epimeron slightly higher than long and rounded with moderate notch in ventral margin dividing it into a larger anterior and smaller posterior lobe; second, third, and fourth joints essentially as in first gnathopod; wrist triangular, about as broad as long with postero-ventral angle rounded and provided with a tuft of setae; hand strong, subrectangular, with anterior margin slightly convex and provided with numerous fascicles of setae, posterior margin also with numerous fascicles of setae, palm oblique and convex, prehensile angle very prominent and acute; finger stout and curved with a few serrations on concave margin fitting behind prehensile angle.

Epimera of second gnathopod and first and second pereopods provided with small notch in ventral margin, dividing epimeron into 2 rounded lobes.

Telson triangular, not as long as wide, apex more or less truncated, provided with 2 fascicles of setae along lateral margins.

One of the specimens, a male, was dredged in 3 fathoms in Castle Harbor, in dead coral, April 24, 1901. The species has been previously reported from the North Atlantic and adjoining seas of Europe between tide marks and at small depths.

***Amphithoe pollex* sp. nov.**

Eyes compound, round, moderate in size.

First antennae with second joint of peduncle slightly longer than first which is moderately stout. Rest of antennae wanting in specimens at hand. Second antennae with gland cone absent, third joint of peduncle broader than long; fourth and fifth joints subequal in length but fifth rather more slender than fourth; flagellum made up of about 10 joints, equal in length to last 2 joints of peduncle together.

First gnathopods with rhomboidal epimeron, rather longer than high and provided with short setae on ventral margin; second joint fairly stout with a semicircular process at antero-distal angle; third and fourth joints short, fourth twice as long as broad with setae on apex; wrist triangular, scarcely as broad as long, with short posterior margin rounded and provided with a few long setae; hand oval, rather large, nearly twice as long as wrist and more than twice as long as broad, widest portion very near proximal end, posterior margin and palm forming an even curve, prehensile angle with a stout

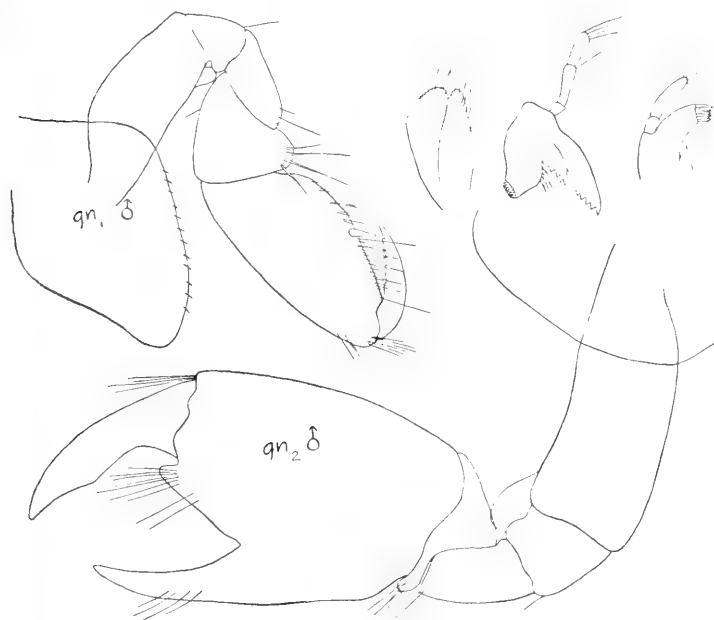


Fig. 36. *Amphithoe pollex* sp. nov.

spine, palm very oblique and provided with numerous setae; finger rather large and stout with concave margin bearing several serrations.

Second gnathopods with rounded epimeron and very stout second joint; fourth joint rectangular, about twice as long as broad; wrist very short, triangular, considerably broader than long, with free posterior margin very short and strongly convex and bearing a fascicle of long setae; hand exceedingly large, broader at distal end than at proximal and somewhat longer than broad at widest part, posterior margin produced to form a long, slightly curved, thumblike process; palm very oblique and shorter than

thumblike process just described, provided with a few long setae near apex, distal margin of hand transverse and rather long; finger stout, with broad base and with concave margin provided with a low broad triangular process.

Epimera rather low, with ventral margins not strongly convex; pereopods fairly stout, first and second provided with spinning glands, fourth and fifth longer than others.

Uropods and telson as in *A. longimana*.

The species was represented in the collection by 2 male specimens, the larger one of which measured 5.5 mm. in length.

Grubia crassicornis (A. Costa, 1853) Della Valle, 1893.

1853. *Amphithoe crassicornis*. A. Costa, Rendic. Soc. Reale Borbon., Accad. Sci. Napoli, vol. 1, p. 306, pl. 3, fig. 1 a-d.

1893. *Grubia crassicornis*. Della Valle, Fauna und Flora des Golfes von Neapel, vol. 20, p. 464, pl. 2, fig. 12; pl. 13, fig. 18-29.

Eyes small, nearly circular, compound and made up of very many ocelli which are yellowish brown in the alcoholic specimens at hand.

First antennae longer than second, with peduncle about $\frac{1}{3}$ length of flagellum; first joint rather stout and about as long as second; third about $\frac{1}{3}$ as long as second; flagellum made up of large number of segments which are furnished with setules distally; accessory flagellum composed of single segment which is about $\frac{1}{2}$ as long as first joint of principal flagellum. Second antennae with gland cone prominent and slender; third joint of peduncle rather long and about as long as fifth which is as long as fourth joint; flagellum made up of many joints, about as long as peduncle.

Mandibles strong, well developed; palp 3-jointed, slender, first joint $\frac{1}{2}$ as long as second, third joint shorter than second and stouter, with apex rounded and provided with numerous long setae; principal cutting edge long with numerous triangular teeth; secondary cutting edge also with numerous teeth; spine row with 6 spines; molar tubercle very large and prominent, provided with 6 or 7 flagella. Lower lip with inner plates large, rounded, with many short hairs on anterior margin; outer plates large, with anterior margin incised with deep, broad notch; mandibular processes long, broad, tapering, and widely divergent. First maxillae with inner plate small, triangular, provided with a single seta on inner margin; outer plate broad, curved, apical margin obliquely truncated and provided with numerous pectinate toothlike spines; palp 2-jointed and slender, first

joint slightly longer than broad, second joint long, tapering, provided with many long setae on distal half of inner margin and apex. Second maxillae with inner plate narrower than outer and tapering slightly, with apex rounded and provided with plumose spines on distal third of inner margin and apex; outer plate slightly longer than inner plate with outer margin rounded, inner margin straight, slightly broader toward distal end than at base and provided with setae. Maxillipeds with inner plates moderately long, provided with many setae distally and on inner margin, apex rounded; outer plate large, inner margin straight, outer strongly convex, provided with many long setae on apex and numerous very short ones on inner



Fig. 37. *Grubia crassicornis* (A. Costa).

margin; palp 4-jointed of which the first joint reaches farther than the inner plate and the second about as far as outer plate and is provided with plumose spines on inner margin, third joint nearly as long as second, more or less oval in form, with many setae on inner margin and a fascicle on outer margin near distal end and a second fascicle at apex, fourth joint conical and provided with a nail apically which equals the joint itself in length.

In female first gnathopods with epimeron about as long as high, with ventral margin much longer than dorsal, convex and furnished with a few very short setae; second joint moderately stout, broader at distal end than at proximal, furnished with 2 long setae on pos-

terior margin, distal anterior corner prolonged into rounded process which bears a single seta; third joint slightly longer than broad, provided with several setae distally; fourth joint broader distally and slightly longer than third and provided with a few setae on distal margin; fifth joint $\frac{3}{4}$ as long as hand, provided with a single seta on middle of posterior margin and another at distal end, and many on anterior margin; hand oval, provided with many setae on anterior margin and several distally and on posterior margin, palm oblique, passing by smooth curve into posterior margin of hand; prehensile spine present, palm provided at articulation of finger with curved spine somewhat smaller than prehensile spine; finger curved and slender, about $\frac{1}{2}$ as long as hand, inner concave margin notched.

Second gnathopods with hand shorter than that of first but about as stout; epimeron subrectangular, slightly higher than long, provided with short setae on convex ventral margin; second and third joints as in first gnathopod; fourth joint longer than broad, with a fascicle of setae terminally, articulating by entire anterior margin with wrist which is subtriangular and nearly as broad as long; posterior margin very strongly convex and provided with several groups of setae toward apex and proximal to these with 5 transverse rows of very short cilia; hand oval, provided with several setae on anterior margin and more closely set setae on posterior, very similar to hand of first gnathopod, palm provided with submarginal setae of various lengths; finger very slender, of usual form.

Pereiopods of anterior group provided with spinning glands; epimera moderate with ventral margins rounded and bearing a few short setae.

Uropods, 3 pairs, biramous; first with long peduncle and with inner ramus, which is the longer, about as long as peduncle, rami terminated by 3 short, stout spines and a single larger one; second uropods extending nearly as far as first, with rami similar to those of first but stouter; third uropods very stout, and extending as far as preceding ones; subequal rami, the inner one of which is provided with 2 curved spines apically and the outer one with a fascicle of setae, rami about $\frac{1}{3}$ as long as peduncle which is moderate in size and provided distally with several short stout spines.

Telson not as long as wide, triangular or semicircular in shape, entire.

Length about 6 mm.

The species is rather common at Naples and has also been recorded from the Black Sea.

Grubia coei sp. nov.

Eyes compound, oval, situated very well forward on interantennal lobes.

First antennae longer than second and nearly $\frac{2}{3}$ as long as body; peduncle more than $\frac{1}{2}$ as long as principal flagellum, first joint stout, cylindrical, nearly as long as head, second nearly as long as first but much more slender; third joint very short, about as long as first joint of flagellum; accessory flagellum one-jointed, not as long as first joint of principal flagellum which is slender and made up of a large number of segments. Second antennae with gland

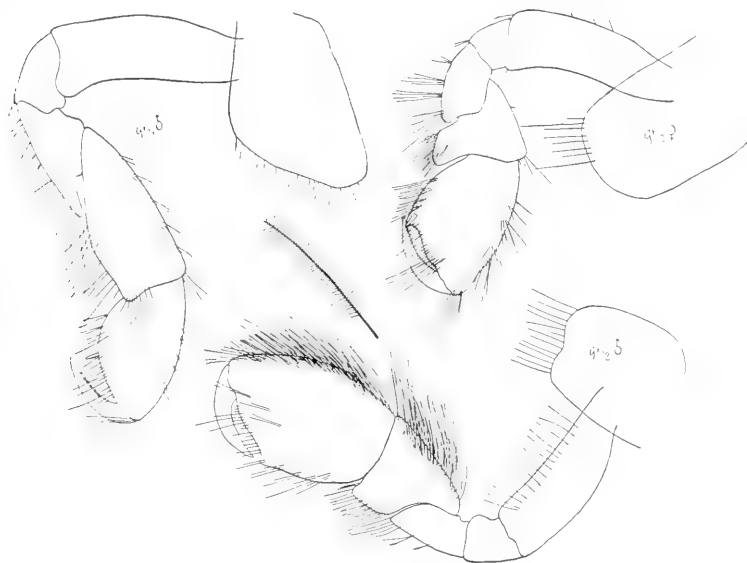


Fig. 38. *Grubia coei* sp. nov.

cone small; third joint of peduncle longer than broad, extending $\frac{3}{4}$ as far as first joint of first antennae; fourth and fifth joints long, subequal, provided with dense plumose spines; flagellum made up of many joints, scarcely as long as peduncle.

Mandibles with all parts well developed; principal cutting edge denticulated, also secondary cutting edge which is long; spine row with 8 spines; molar tubercle large and prominent; palp 3-jointed having the second joint longer than third, which is stouter than second and with rounded apex provided with numerous setae. Lower lip with outer plates large, having anterior margin deeply incised and mandibular processes prominent; inner plates large and

oval. First maxillae with 2-jointed palp, of which the terminal joint is club-shaped with sharp spines on apical margin; outer plate rather large with obliquely truncate apical margin provided with branched spines; inner plate very small, triangular, provided with setae on inner margin. Second maxillae with outer plate longer than inner and much broader apically than proximally, provided with setae apically; inner plate tapering, with rounded apex, which, with inner margin, is provided with plumose spines. Maxillipeds with plates well developed and with 4-jointed palp; inner plate extending about as far as apex of first joint of palp, rounded and provided with plumose spines and with apical odontoid spine; outer plate large, oval, extending beyond apex of second joint of palp; inner margin armed with odontoid spines which increase in length and become slender distally; palp with first joint triangular, short, second joint cylindrical with spines near distal end of inner margin, third joint short, broader distally, with setae on distal half of inner margin and apex, fourth joint curved, conical, armed with clawlike spine apically and several setae on inner margin.

In male, first gnathopods with triangular epimeron bearing setae on ventral margin, about as high as greatest length; second joint rather long and slender with small rounded process at distal end of anterior margin; third joint short, more or less triangular; fourth joint moderately long, with long, rather slender process at distal end of posterior margin, so that posterior margin, which is provided with setae, is much longer than anterior, distal margin oblique, articulation with wrist rather short; wrist very long, as long as second joint and much stouter, articulating with fourth joint by proximal part of posterior margin, distal portions of posterior and anterior margins parallel, distal margin transverse, margins provided with setae; hand oval, stout, palm very oblique, slightly convex, posterior margin very convex, separated from palm by prehensile spine, anterior margin moderately convex, hand broader than wrist but shorter, slender setae on palm, posterior and anterior margins; finger moderately long, with serrated concave margin.

Second gnathopods with epimeron rectangular, slightly higher than long with ventral margin provided with long setae and slightly indented by broad sinus; second joint rather long with anterior margin provided with setae; third joint of usual form, about as long as broad; fourth joint rectangular, with posterior margin provided with setae near distal end and longer than anterior, apex somewhat oblique; wrist triangular, articulating with almost entire anterior margin of fourth segment, posterior margin provided with short

setae and strongly convex to form rounded lobe which extends as far as posterior margin of fourth joint, anterior margin slightly convex and provided with large number of very long plumose spines; hand oval, not much longer than broad, wider than wrist, anterior margin with very large number of long plumose spines, posterior margin with several fascicles of setae, both margins rather convex, palm oblique, marked off from posterior margin by slight triangular process, provided with setae of various lengths; finger short and stout.

In female first gnathopods with epimeron having anterior ventral corner rounded and projecting considerably so that ventral margin is nearly twice as long as dorsal, provided with long setae; second joint moderately long and slender, with setae on posterior margin and rounded lobe at distal end of anterior margin; third joint longer than broad; fourth joint broader distally than proximally, with posterior margin much longer than anterior and provided with numerous setae; wrist somewhat triangular, twice as long as broad, articulating with oblique distal margin of fourth, anterior margin much longer than posterior so that distal margin is transverse, posterior margin provided with numerous long setae; hand scarcely as long as wrist and about as broad, oval, posterior margin short, palm very oblique, separated from posterior margin by prehensile spine, anterior and posterior margins provided with numerous fascicles of setae, palm provided with numerous submarginal setae of various lengths; finger moderately strong with inner margin only slightly concave and serrated.

Second gnathopods with rectangular epimeron higher than long, with rounded ventral margin provided with long setae; second joint similar to that of first gnathopod; third short; fourth rectangular twice as long as wide, with posterior margin longer than anterior and provided with several fascicles of setae; wrist triangular, broader than long and with posterior margin produced to form rounded lobe which is densely covered with setae; hand longer than broad with distal end broader than proximal, palm slightly oblique, provided with numerous submarginal setae, separated from posterior margin by slight process and prehensile spine, anterior and posterior margins provided with numerous fascicles of setae; finger of usual form and size. In both sexes second gnathopods larger than first.

Epimera increasing slightly in height to fifth, all provided with setae on ventral rounded margins.

Cropods biramous; first and second pairs with inner ramus slightly longer than outer, second pair projecting hardly as far as first; rami

provided with short setae on inner margins and apex; third uropods with short conical rami armed apically with hook-like spines, extending beyond other uropods.

Telson small, entire, thick, subtriangular, about as long as broad.

In the alcoholic specimens represented in the collection by 2 males and 2 females, the epimera, terga, and proximal joints of the antennae and uropods were marked with irregular spots of a dark flesh color. Length of males, 10 mm.; of females, 18 mm.

Eriethonius braziliensis (Dana, 1853) Stebbing, 1906.

1853. J. D. Dana, *Pyctilus braziliensis*. U. S. Explor. Exped., vol. 13 II, p. 976; pl. 67, fig 5.

1906. Stebbing, *Eriethonius braziliensis*. Das Tierreich, Lief. 21, p. 671.

Eyes compound, with ocelli very closely crowded together, situated on basal portion of very prominent interantennal lobes.

Antennae subequal and more than half as long as body.

Mandibles with all parts well developed; palp stout, 3-jointed; first joint broader than long, narrower at base than apically; second joint longer and stouter than first, armed with long slender setae on inner margin; third joint nearly 3 times as long as broad, with rounded apex, armed with setae along inner margin, more numerous on distal half and apex, outer margin with fascicles of setae at middle; cutting edge short, divided into 4 or 5 teeth, of which the second is the largest; secondary cutting plate expanded distally and cutting edge very oblique, composed of 4 rather sharply pointed teeth, diminishing in size from the anterior one; 5 plumose spines on spine row; molar tubercle moderately large. Lower lip with outer plates having anterior margin entire, inner plates moderately developed. First maxillae with inner plate small, triangular, with 2 setae on inner margin; outer plate moderately broad, tapering slightly, with 7 forked spine teeth on distal margin; palp 2-jointed, curved; first joint broader than long; second about as long as wide with apex truncate, armed with 4 stout setae and several smaller ones. Second maxillae with broad plates rounded distally; outer plate longer than inner one and with setae on apex; inner plate with spines on apex and diagonally on surface. Maxillipeds with long, 4-jointed palp; fourth joint cylindrical, about twice as long as broad, with 4 apical setae, of which the 2 outer are longer than segment; third joint stout, twice as long as broad with numerous long setae on distal portion; second joint broader and longer than third and armed with long setae on inner margin; first joint slightl.

longer than broad; outer plate extending scarcely to middle of second joint of palp, armed with plumose spines on rounded apex, the spines becoming smaller as they pass obliquely over the surface to inner margin proximally, margin with dagger-shaped spines on distal portion of inner margin; inner plate rather rectangular in shape, extending as far as first joint of palp, armed with plumose spines apically and on distal half of inner margin; apex with 3 odontoid spines.

In male first gnathopods with small epimeron; second joint rather

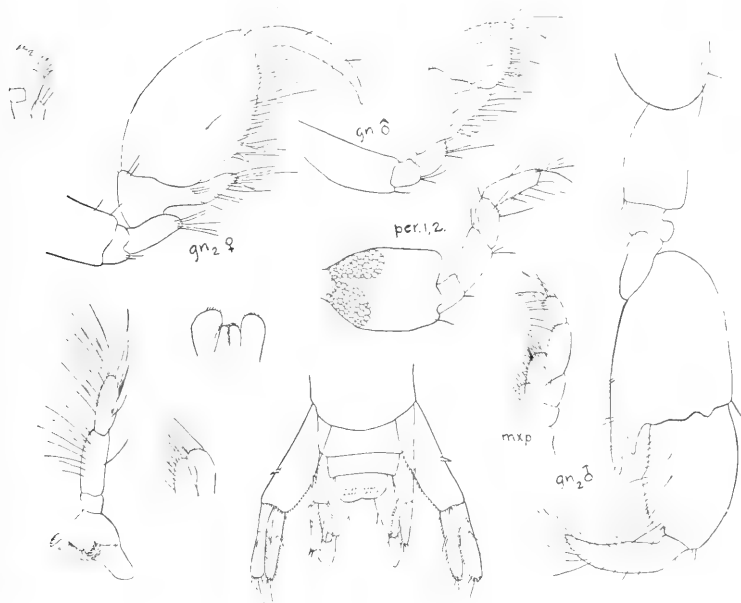


Fig. 39. *Ericthonius braziliensis* (Dana).

short, about 3 times as long as broad; third and fourth joints short, fourth bearing a few setae apically, third bearing fewer and shorter ones; wrist large, triangular, somewhat longer than broad, attached to anterior margin of fourth, posterior margin provided with many long setae; hand, triangular, as broad as wrist but not so long, about as long as broad, with 4 fascicles of setae near anterior margin, posterior one very short and convex with several moderately long setae, passing into palm by even curve; palm finely serrate, provided near proximal end with a single stout plumose spine and numerous setae of various lengths; hand provided apically with

several long setae; finger moderately long and curved, with one seta near middle of outer convex margin and another near proximal end; finely serrate on inner margin.

Second gnathopods with epimeron rounded ventrally, with a single seta anteriorly; second joint rather stout, armed with a very few short setae on anterior and posterior margins; third joint not as long as broad; fourth joint oblong, more slender than third and about 3 times as long as wide; wrist very large and strong, subtriangular in shape, considerably longer than broad; posterior margin prolonged to form a large process extending past base of hand in the form of 2 moderately sharp toothlike projections, of which the outer one is the longer, posterior margin bearing 4 fascicles of short setae toward distal end; hand subrectangular and smaller in all dimensions than wrist, very markedly narrower, anterior margin convex, posterior margin about $\frac{1}{3}$ as long as anterior and parallel to it, palm longer than posterior margin and very oblique, passing into posterior margin by a slightly projecting obtuse prehensile angle, palm provided with setae of various lengths; finger long, curved, stout, nearly equalling the hand in length so that apex fits into notch between process of wrist and hand, provided with short setae which are longer and more crowded together around apex.

In female, second gnathopods simply subchelate; wrist provided with long process on posterior margin which extends nearly as far as proximal end of palm, process provided with setae along posterior margin and at apex where there are also 2 odontoid spines; hand oval with distal portion more slender, transition between posterior margin and palm by an even curve which is provided with 2 or 3 prehensile spines; finger slender, moderately long and curved, armed with a few setae.

Pereiopods with low epimera; first, second, and third pereiopods rather short and stout with moderately long and slender dactyls; first and second appendages with spinning glands; fourth and fifth appendages rather long and slender.

Uropods, 3 pairs; first pair longest, with peduncle serrate on inner margin and slightly longer than rami which are subequal and have margins finely serrate and provided with 2 short stout spines and with one long stout spine and several shorter setae on apex; second pair not extending as far as others, similar to first pair; third pair with stout peduncle and single ramus which is stout and projects as far as first uropods, somewhat curved in form and provided apically with 2 very short, stout, hooked spines.

Telson broad but short, not extending as far as peduncle of second

uropods, apically rounded with broad, shallow depression dividing it into 2 lobes which are armed on the dorsal surface with numerous recurved spines.

There were only 2 or 3 specimens of the species in the collection, about 4 mm. in length. The species has been previously reported from the Atlantic coast of N. America (Vineyard Sound), Norway, the Adriatic, Rio Janeiro, and the North Pacific (San Francisco).

Chelura terebrans Philippi, 1839.

1839. Philippi, Arch. f. Naturgesch., vol. 5, p. 120, pl. 3, fig. 3.

Eyes round, compound, situated close to lateral lobes of head.

First antennae about $\frac{1}{5}$ as long as body, with joints of peduncle successively diminishing in size; principal flagellum about as long as last 2 joints of peduncle, composed of 6 joints rather densely provided with slender setae; accessory flagellum short, made up of 2 joints. Second antennae much longer and stronger than first and somewhat curved; third, fourth, and fifth joints of peduncle nearly equal in length, fifth being longer than either fourth or third: flagellum not segmented, consisting of a large spatulate joint provided with dense setae on both edges and tipped with one or two rudimentary segments.

Upper lip rather elongated with apex broad and entire. Mandibles with strong body but relatively small palp; principal and secondary cutting edges denticulated, molar tubercle strongly developed: palp 3-jointed with terminal joint longest and having acute apex armed with several long setae and inner margin beset with short setae, second joint cylindrical, about twice as long as wide; first joint very short. Lower lip made up of 2 pairs of plates with cilia on anterior margin of outer plates. First maxillae with inner plate moderately developed, provided with several setae on apex; outer plate strong, provided with many strong, branching spines; palp moderate, composed of 2 joints of which the distal one is the longer with rounded apex which is provided with setae of various lengths. Second maxillae with plates rather narrow and provided apically with setae. Maxillipeds with well developed plates and 4-jointed palp; inner plate with rounded apex and extending nearly as far as distal end of first joint of palp, with slender setae on inner and apical margin; outer plate with outer margin rather strongly convex, inner margin straight and apex fairly acute, both provided with setae; palp with second joint long and slender, slightly spindle-shaped with setae on inner margin, third joint about twice as long as broad, with outer apex produced to rounded lobe, fourth joint

slightly curved, cylindrical, much smaller than third joint, provided apically with clawlike spine.

First gnathopods with rectangular epimeron about as long as broad and with angles rounded, and with anterior ventral angle provided with long setae; second joint rather stout, with anterior and posterior margins parallel and provided with long setae; third joint very short; fourth joint about as broad as long with apex rounded and armed with a fascicle of setae; wrist short, subrectangular with anterior margin longer than posterior and with the latter provided with long setae; hand subrectangular, about twice as long as broad and much longer than wrist, with posterior apex produced to form a stout thumb against which the finger closes; finger curved, small.

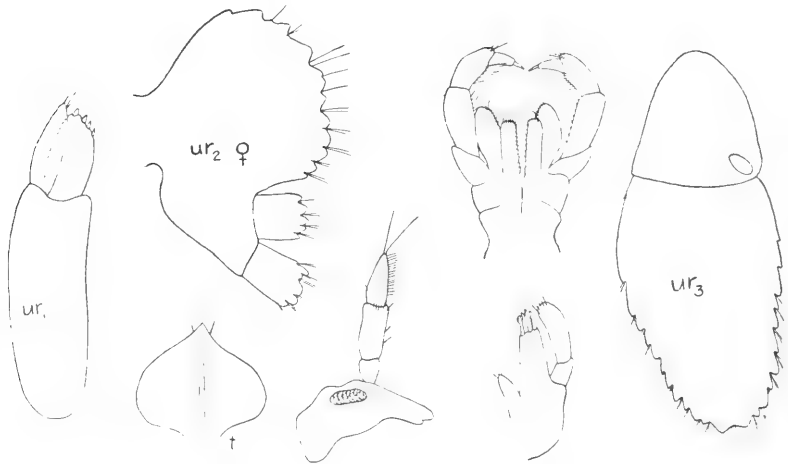


Fig. 40. *Chelura terebrans* Philippi.

Second gnathopods with small triangular epimeron provided with stout spines; second joint rather longer and more slender than that of first gnathopod with anterior margin provided with long setae; third joint shorter than broad; fourth joint triangular, nearly twice as long as broad with anterior and posterior margins slightly convex, anterior margin and apex provided with rather long, plumose spines; wrist subrectangular, as long as but narrower than preceding joint; hand subrectangular, very long and slender, being longer than fourth joint but much narrower, smaller than that of first gnathopod, posterior apex prolonged to form rounded thumb against which the strongly curved but short finger closes to form a chela.

Epimera of pereopods rather small, pereopods subequal in length

and rather short and stout, second joints of posterior pairs scarcely broader than those of anterior pairs; posterior pereopods with posterior margin fringed with strong ciliated setae.

Posterior abdominal segments fused, about $\frac{1}{2}$ as long as body in male, $\frac{1}{3}$ in female; dorsal posterior margin of third segment produced to form long projection, slightly curved, directed posteriorly, which is much longer in male than in female.

Uropods, 3 pairs; first pair biramous with long cylindrical peduncle and rather short styliiform rami scarcely half as long as peduncle, inner ramus somewhat broader than outer and armed apically with 3 short spines; second pair rather short, biramous, with lamelli-form rami which have 5 or 6 serrations apically and are scarcely half as long as peduncle which is expanded greatly to form a subquadrate lobe having serrated outer margin; third pair with short peduncle and single rather long, oval ramus which is leaflike and serrated on edge.

Telson small, triangular, subcarinated dorsally, apex acute.

Length of female 5 mm., of male (exclusive of terminal uropods) 6 mm.

Sexual differences rather marked; in male, dorsal projection from third abdominal segment relatively much longer than in female; second pair of uropods with expansion of peduncle broader than long and with serrated margins, whereas in female the expansion is long and provided with many closely set long spines; third uropod with much longer ramus than in female.

A large number of specimens were obtained from the neighborhood of Coney Island in submerged timbers which were thoroughly honey-combed with the tunnels of the animal.

The species has been recorded from the North Atlantic and adjoining seas (Europe from Norway to the Black Sea, North America).

Tribe LAEMODIPODA.

First thoracic segment fused with head; eyes small, compound; mandibles with or without palp; first maxillae without inner plate; maxillipeds normally developed with 1- to 4-jointed palp.

Pereopods, when not rudimentary, ending in prehensile claws. Abdomen short and small with or without appendages.

The tribe is divided into 2 families, the Caprellidae and the Cyamidae, characterized as follows:

Caprellidae.

Body slender, first antennae much longer than second. Gills saclike and confined to the second, third, and fourth, or to only the third and fourth thoracic segments.

Abdomen of 5 joints at most, of which the first 3 are very short and do not bear appendages; uropods rudimentary or obsolete.

Non-parasitic in habit.

Cyamidae.

Body broad and flat; third and fourth thoracic segments without limbs, posterior segments with prehensile limbs.

Both pairs of antennae 4-jointed, first pair much longer and stouter than second.

Gills confined to third and fourth thoracic segments, elongated in form.

Parasitic on Cetacea.

Key to the genera of the Caprellidae.

- Mandibles without palp **Caprella**
- Mandibles with palp **Protellopsis**

Caprella equilibra Say, 1818.

1818. Say, Journ. Acad. Natur. Sci. Phil., vol. 1, p. 374-401.

Eyes compound, moderate in size. Rostrum absent. Body with smooth dorsum.

First antennae with peduncle stout, having third joint longer than first and second longer than third; flagellum abruptly narrower than peduncle, made up of about 12 joints, less than 1/3 as long as peduncle. Second antennae fringed with long setae; flagellum made up of 2 joints, nearly as long as fourth joint of peduncle which is as long as fifth, provided with long setae, terminal joint small.

Mandibles without palp; cutting edge divided into about 5 acute teeth; spine row with 2 or 3 stout plumose spines; molar tubercle strong, with a triangular process which gives it an irregular shape in the side view. Lower lip with principal lobes widely dehiscent; inner lobes fairly large; mandibular processes narrow, rather widely dehiscent. First maxillae with no inner plate; outer plate curved, shorter than palp, with distal margin furnished with 7 forked tooth-like spines; first joint of palp short; second widening toward dentated, obliquely rounded apex which is provided with many setae on margin and with row of longer ones on surface near apical

margin. Second maxillae with inner plate shorter than outer, with many slender setae around margin; outer plate oblong with long setae on apex. Maxillipeds with inner plate small, scarcely reaching to base of first joint of palp, distal margin transverse and provided with 2 or 3 spine teeth; outer plate small, extending slightly beyond first joint of palp; with 8 rather long spine teeth on distal part of inner margin and long setae which also arm the oblique distal margin; palp 4-jointed with first joint small and moderately stout, having a few setae on inner margin; second joint stouter and much longer, about twice as long as wide, with inner margin provided with many long setae; third joint shorter and more slender than second and with fringe of long setae on inner margin and apex; fourth joint unguiform, as long as third joint.



Fig. 41. *Caprella equilibra* Say.

First gnathopods with second joint moderately short; third and fourth joints short, fourth with a fascicle of long setae on distal portion of posterior margin; wrist about as broad as long, with setae on rounded posterior margin; hand oval, about twice as long as wide, tapering toward distal end, anterior margin convex, posterior margin very short, palm extending practically to base of hand, and provided with setae of various lengths and a stout prehensile spine, posterior part of palm finely serrate; finger long and strong with inner concave margin toothed.

Second gnathopods rather short and stout, with distal end much broader than proximal and with lamellar process extending along anterior margin; third, fourth, and fifth joints short; hand oval, long, with long palm bearing 2 or 3 rounded processes about middle and several short setae, prehensile angle prominent, terminating in stout spine; finger strong. "Of special importance as a character of the

species is the strong sharp process projecting ventrally in the middle line between the insertions of the second gnathopods of the male, which is developed only slightly in the female." (Mayer.)

Pereiopods, first and second pairs wanting, third pair present. Gills present on third and fourth thoracic segments, long and narrow. Abdomen with single segment. Uropods, one pair present in male, wanting in female.

There were several specimens in the collection, the longest of which was hardly 10 mm. in length.

The species is widely distributed, having been recorded from the Mediterranean; the coast of Norway; Charleston, S. Car.; Hongkong; Rio Janeiro; and New South Wales.

Caprella bermudia sp. nov.

Eyes small, round, situated well posterior to front margin of head.

First antennae stout, more than $\frac{1}{2}$ as long as body; peduncle somewhat longer than flagellum which is composed of 12 or more elongated segments: first joint of peduncle short and thick, second joint nearly twice as long as first and not so thick, and provided with a row of long setae on distal half of lower margin; third joint somewhat longer than first, cylindrical in form and provided on lower margin with many short setae. Second antennae slightly longer than peduncle of first; second joint of peduncle very short with inconspicuous gland cone; third joint about twice as long as wide; fourth and fifth joints subequal in length and provided on lower margin with rather long setae: flagellum made up of 2 joints, about as long as fifth joint of peduncle, first joint 3 or 4 times as long as terminal joint and provided with setae on lower margin.

Mandibles without palp, principal cutting edge divided into 5 unequal teeth, secondary cutting edge divided into 5 equal teeth, molar tubercle large, of irregular form. Lower lip with large rounded inner lobes and principal lobes with anterior margin entire, mandibular processes short and stout. First maxillae with 2-jointed palp, of which the last is long and abundantly provided with spines toward apex where joint is widened; outer plates rather short; inner plates wanting. Second maxillae with inner plate shorter than outer but wider at base than outer plate, both with distal margins rounded and provided with setae. Maxillipeds with outer and inner plates rather small; palp long and 4-jointed; inner plates broader distally than proximally, distal margin straight, oblique, provided with numerous setae: outer plates extending slightly beyond first-joint of palp, outer margin and apex rounded, inner margin with 5

or 6 sharply pointed toothlike spines and numerous setae; first joint of palp short, outer margin rather longer than inner, second joint about twice as long as wide with setae on inner margin, third joint about as long as second but more slender, provided with setae on inner margin toward apex; terminal joint clawlike, nearly as long as third joint.

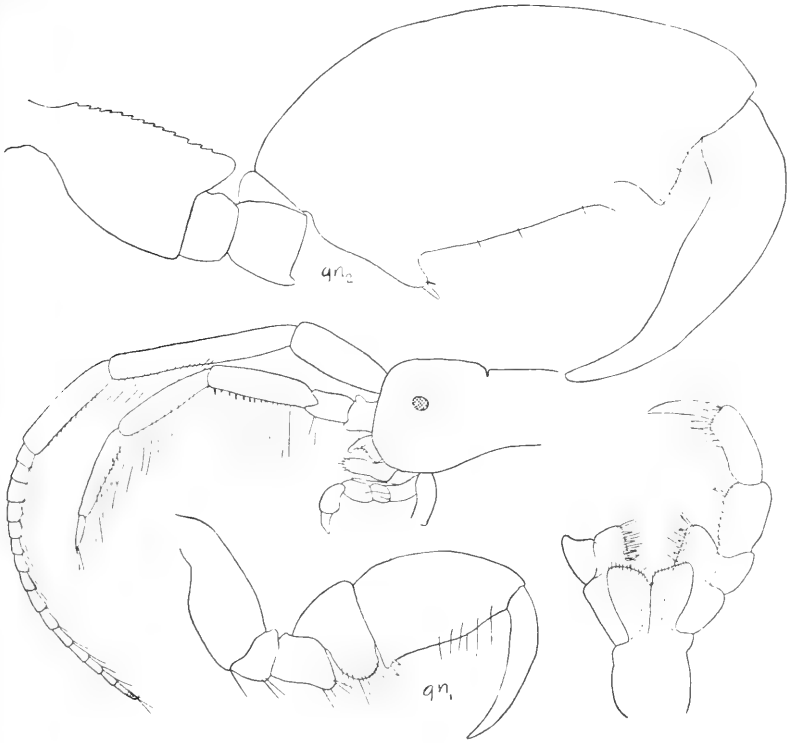


Fig. 42. *Caprella bermudia* sp. nov.

. In male, first gnathopods with second joint very short and stout; third joint broader than long; fourth joint subrectangular with group of setae on distal margin; wrist somewhat triangular, posterior margin strongly convex, forming semicircular lobe, provided with about a dozen setae; hand subtriangular, as broad as wrist and about twice as long as broad, anterior margin convex, palm forming posterior margin, very slightly convex, with 2 prehensile spines and a few slender setae; finger long and not greatly curved, moderately slender.

Second gnathopods very large; second joint about twice as long as wide at distal end, proximal end rather narrow, anterior margin notched and slightly convex, anterior apex produced, forming a triangular process, posterior margin rather strongly convex; third joint shorter than long; fourth joint about as long as broad, rectangular with small process extending from distal end of posterior margin; wrist very small, articulating with anterior margin of fourth joint; hand large, suboval, anterior margin slightly convex; palm rather long and very oblique, nearly parallel with anterior margin, separated from posterior margin by rather prominent process bearing prehensile spine, palm provided with a rather deep notch near distal end, behind which is a toothlike process, proximal to which the palm is nearly straight and less prominent than toward the distal end; finger stout and curved, moderately long.

Second thoracic segment provided with long acutely pointed process ventral to articulation of gnathopod which is near posterior end of segment. Pereiopods of third and fourth segments wanting. Branchial vesicles narrow, 3 times as long as broad, present on third and fourth thoracic segments. Fifth, sixth, and seventh pereiopods of usual form.

Abdomen represented by a single segment with a single pair of rudimentary uropods.

Length about 9 mm.

There were 2 specimens collected by Dr. L. J. Cole, July 15, 1903.

Caprella danilevskii Czerniavski, 1868.

1868. *Materialia ad zoograph. pont. campar.*, p. 92; pl. 6, fig. 21-34.

The following description is modified from Haswell's of *C. inermis* which is evidently the same as *C. danilevskii*. (*Proc. Linn. Soc. N. S. Wales*, vol. 4, p. 348. 1879.)

Cephalon terminating anteriorly in minute mesial tooth. Neck very long; first segment of body longer than head and neck, other segments shorter.

First antennae as long as head and first 2 thoracic segments; flagellum shorter than last 2 segments of peduncle. Second antennae slightly longer than peduncle of first; flagellum shorter than last 2 joints of peduncle.

First gnathopods short with ovate hand having a longitudinal palm which is undefined.

Second gnathopods very large, with hand elongated and narrow with the palm uniformly excavate and occupying $\frac{1}{3}$ entire length of hand.

Gills subcylindrical.

Last pair of pereopods longer than others.

Color, green.

Length $\frac{7}{10}$ in.

The species is of exceedingly wide occurrence, having been already reported from the Mediterranean, Black Sea, Copenhagen, Bay of Biscay, Sea of Japan, Port Jackson (New South Wales), Rio Janeiro, and Bermuda (Stebbing, 1888, Challenger Report, vol. 29, p. 1264).

No specimens of this species were present in the collection studied.

***Protellopsis stebbingii* Pearse, 1908.**

1908. A. S. Pearse, Proc. U. S. Nat. Mus., vol. 34, p. 30.

Head rounded and provided with acutely pointed spinous processes. There may be 2 processes directed forwards and situated above and behind the eye, or there may be a single process in the middorsal line and also one just lateral to the base of the second antennae. Second thoracic segment with spinous process in middorsal line situated at about middle of segment, anterior margin with large process laterally and also several just dorsal to articulation of second gnathopod. These processes are variable in size and occurrence.

Eyes large, circular, situated near anterior margin of head.

First antennae rather slender, more than $\frac{1}{2}$ as long as body; peduncle over $\frac{1}{2}$ as long as flagellum which is made up of numerous elongated segments; first joint of peduncle moderately stout, cylindrical; second joint about twice as long as first and not so broad; third joint less than $\frac{1}{2}$ as long as first, broader at distal than proximal end. Second antennae much shorter than first, extending as far as first third of flagellum of first; flagellum 2-jointed, first joint $1\frac{1}{2}$ times as long as distal one, as long as fourth joint of peduncle; gland cone rather prominent; third joint longer than broad; fourth and fifth joints subequal and slender, with a few setae.

Mandibles with 3-jointed palp, of which the first is short and cylindrical and about twice as long as broad; second joint slender, of about the same width as first but more than twice as long; third joint shorter than second, broader at distal end than at proximal, apex obliquely truncated and provided with setae of various lengths; principal and secondary cutting edges divided into numerous teeth;

molar tubercle large, cylindrical. First maxillae without inner plate; outer plate narrow, provided with serrated toothlike spines on short apical margin; palp 2-jointed, first joint about as broad as long, second twice as broad as long with apex rounded and broader than proximal end and provided with short spines. Second maxillae small, outer plate longer and narrower than inner plate, both plates with fine setae on apex. Lower lip with principal plates broad and oval; inner plates rather large; mandibular processes short. Maxillipeds with outer and inner plates small and with long, 4-jointed palp; inner plates not reaching as far as base of first joint of palp, rather broad and with apical margin rounded and provided with a few stout spines; outer plates extending to about the middle of

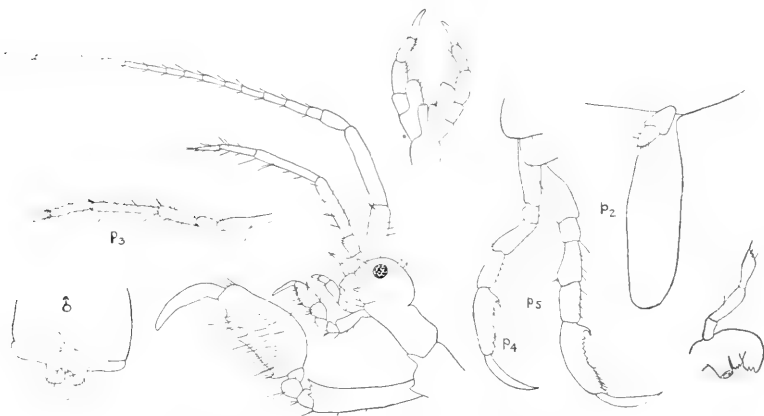


Fig. 43. *Protellopsis stebbingii* Pearse.

second joint of palp, outer margin rather strongly convex, inner margin straight and provided with a few setae; palp with first joint longer than broad, cylindrical, second joint cylindrical, 3 times as long as broad; third joint somewhat shorter than second and narrower, provided at distal end of inner margin with a few setae; fourth joint clawlike and as long as third, provided on inner margin with exceedingly fine setae.

First gnathopods with second joint moderately slender; third joint about as broad as long; fourth joint more or less cuplike and with posterior margin much longer than anterior and provided with a few setae near apex; wrist triangular, rather longer than wide, posterior margin and apex provided with a few short setae; hand triangular, about $1\frac{1}{2}$ times as long as wide and much wider than wrist,

palm oblique, forming nearly entire posterior margin, provided with numerous short setae; finger rather long and curved, concave margin somewhat serrated.

Second gnathopods with second joint long and slender and slightly curved so that posterior margin is slightly convex, anterior apex produced to form acutely pointed process; third joint about as broad as long; fourth joint spheroidal, articulating with third joint by rather slender stalk, provided with a few setae posteriorly; wrist very short, triangular; hand strongly developed, oval in form, broadest about $\frac{1}{3}$ distance from proximal to distal end, palm extending to very near proximal end of posterior margin and somewhat incised, posterior margin separated from palm by rather prominent triangular process which bears apically a stout spine, form of palm variable, but always with deep U-shaped notch toward distal end; finger very long and curved.

First and second pereopods rudimentary and 2-jointed. Branchial vesicles confined to third and fourth thoracic segments, long and oval in form. Third, fourth, and fifth pereopods developed normally.

Abdomen made up of 2 segments. Uropods, only one pair which are very short and 2-jointed, with the terminal joint exceedingly small and rounded, the first joint broader apically than proximally and bearing several setae apically.

Length 9 mm.

The species was represented by numerous specimens received from Dr. L. J. Cole and bearing the date July 15, 1903.

According to Pearse this species was abundant in the Gulf of Mexico, off Northwest Channel, in $10\frac{1}{4}$ fathoms.

Pearse figures the second gnathopod of the male with the proximal end of the hand broadened to form a triangular process and with the palm bearing a very large triangular notch. In the specimens from Bermuda the second gnathopod of the males does not differ from that of the females which corresponds with that figured by Pearse.

Cyamus fascicularis Verrill, 1903.

1903. Trans. Conn. Acad. vol. 11, p. 21; pl. 8, fig. 4.

A slender bodied *Cyamus* from the body of a young sperm whale, taken off Bermuda and exhibited at St. George's in April.

"This species is much more slender than those of the right whales and allied cetaceans. The two branchial segments are about as wide as the following ones, and bear fascicles of small, short, some-

what unequal branchiae, scarcely longer than the segments. There are about 10 to 12 branchial filaments in each of the four groups.

"The first segment is consolidated with the head, which is narrow and rather long with conspicuous eyes. Antennae are about $\frac{2}{3}$ the length of the head. First pair of legs small, beneath the second. The hands of the second pair are not much swollen, and have two strong denticles, besides a similar one at the distal angle of the carpus. The three posterior feet have a recurved denticle on the distal angle of the carpus.

"Color, yellowish white; branchiae have small black spots. The specimens described are females. No males were taken.

"Length of body und head, 9 mm.; greatest breadth of body, 3.5 mm."

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The Clausula
in
Ammianus Marcellinus

BY

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INTRODUCTION.

The purpose of this treatise is to present the results of an investigation into the nature of the rhythm that characterized the prose of Ammianus Marcellinus, the great historian of the fourth century. Inasmuch as the subject is by no means an entirely new one, it is fitting that we should begin by passing in brief review the facts already established.

The fundamental features of the rhythm employed by Ammianus were pointed out some years ago by Wilhelm Meyer of Speyer in his review of Havet's book, *La prose métrique de Symmaque*.¹ Meyer discovered that in common with a large number of authors, both Latin and Greek, from the fourth century on, Ammianus makes use of accentual clausulae,—in other words, that he secures a rhythmical effect in his prose by contriving that each clause shall end in one or another of a limited number of accentual cadences. As a general definition of the character of these cadences Meyer formulated the following rule:

Both in the Greek and in the Latin accentual clausulae the rule holds good that either two or four (rarely three) unaccented syllables separate the accented syllables of the last two words in the clause.

Now this is a sweeping generalization, and as such it has the faults that are consequent upon its merits. For in the first place, although it holds good in the case of many (probably the majority) of the Latin writers, there are on the one hand some who entirely avoid the use of clausulae in which three syllables separate the accents, and on the other hand some, like Ennodius, who employ these cadences even more extensively than those in which there are four intervening syllables. And in the second place, granted its general truth, it remains an inadequate definition of the Latin clausulae, for it leaves out of consideration two important factors, to wit, the question of the number of the syllables which follow the last accent, and the matter of word-division.²

¹ *Gött. gel. Anz.* 1893, 1-27 = *Ges. Abh. zur Mittellat. Rythmik* II, 236-286. References to Meyer will hereafter be made to the reprint.

² It is not in a spirit of carping criticism that I bring up these points, but simply as a protest against a growing tendency to view this statement as a law of Latin prose-rhythm, whereas it is nothing more than a convenient expression of the extent to which Latin usage, taken by and large, agrees with Greek usage.

These deficiencies are made good, however, by Meyer's list of the various clausulae that he found in current use among Latin authors. This list I reproduce in substance, though not in form, since to avoid possible confusion it seems best to translate his data into the terms of the classification which I have adopted. The essential feature of this classification is that it groups the clausulae first into *forms* on the basis of the accentual cadences they present, and then into *types* of each form on the basis of word-division.¹ In the graphic illustrations of the different forms the sign \sim denotes a syllable, and accented syllables are distinguished from those unaccented by a superposed cross.²

Clausulae in which *two* unaccented syllables come between the accented syllables

I $\overset{\times}{\sim} \sim \sim \overset{\times}{\sim}$

Types³: (γ) *transfere sermonem*, (δ) *accipimus dictum*, ($\gamma \delta$) *dicta sint carptim*

II $\overset{\sim}{\sim} \sim \sim \overset{\sim}{\sim} \sim$

Types: (γ) *suscepi provinciam*, (δ) *animi poscitur*, ($\gamma \delta$) *argumento vel ordine*

Clausulae in which *four* unaccented syllables come between the accented syllables

III $\overset{\times}{\sim} \sim \sim \sim \sim \overset{\times}{\sim}$

Types: (δ) *lapide disparatae*, ($\delta \epsilon$) *lapide sic paratae*, (γ) *deseruisse convincebatur*

IV $\overset{\sim}{\sim} \sim \sim \sim \sim \overset{\sim}{\sim} \sim$

¹ The terms *form* and *type* are borrowed from Zielinski (*Philol. Supplementbd.* IX p. 606), and the classification is parallel to his. Meyer's system is not strictly logical, nor is it flexible enough; though by emphasizing the type-distinctions in forms I and II it has the merit of accenting their stylistic importance.

² In the face of Zielinski's protest I retain Meyer's sign $\overset{\sim}{\sim}$; note, however, that I do not use it to express the fact that a syllable may be either long or short, but simply to avoid implication of its quantity. It is therefore employed only when syllable-count is in question and not quantity, and for this purpose it is indispensable.

³ The Greek letters that denote the types are easily fixed in mind by connecting δ with *diacresis*. The system of nomenclature is fully explained on p. 178.

Type: (δ) agitans ignobilibus

Clausulae in which *three* unaccented syllables come between the accented syllables

A $\sim \sim \sim \sim \sim \sim$ ¹

Only type: ille properabat.

Far the most frequent of these forms in general use are I, II and III, although their types are not all held in equal favor. Some writers, as Sedulius, strenuously avoid I δ and II δ (*accipimus dictum, animi poscitur*); Ammianus, however, uses both of these clausulae very freely. The common type in III is δ : for the clausula III γ Meyer cites only Ammianus. So too for the clausula IV reference is made only to Ammianus. Meyer found 46 occurrences of III γ and IV (which he lumped together) among 800 sentence-endings. As for the clausula A, it occurs only with the cæsura after the first unaccented syllable (*ille properabat*), and is rare in most authors. In Ammianus Meyer observed 15 cases among his 800 sentence-endings, in Sedulius 11 among 1000; and he noted that the clausula is in special favor with Ennodius and Gelasius.²

These, then, are the accentual cadences upon which the rhythm of late Latin prose is based. The history of their origin in earlier quantitative clausulae and of their persistence through the Middle Ages in the so-called *cursus* has been discussed at length and in detail by Meyer, and to have established the course of this long development is not the least of the achievements that earn him the title of bene meritus. Into this matter, however, we cannot enter at present: we shall return to it later to consider the genesis of the accentual clausula in the light of Ammianus' testimony, which illuminates certain dark places.

At the outset of our discussion it is well that we should recall to mind a truth that has been voiced of late by Blass, to the effect that the character of the prose-rhythm in any text can not be established

¹ My object in not numbering this form consecutively with the others is primarily to save the numbers V and VI for possible clausulae with six unaccented syllables between the accents (v. p. 168 ff.) and secondarily to emphasize its distinction both in origin and in rhythm from the other four forms (v. p. 199). The reason for giving it the letter A is manifested in the table of cadences, p. 168).

² This statement, as regards Ammianus, stands in need of correction. Type *ille properabat* of A occurs in the text as we have it only about once in 300 clausulae, hence it is to be eliminated as a characteristic of Ammianus' style. V. p. 175.

with entire soundness unless the text itself is entirely sound.¹ Now the text of Ammianus is unfortunately anything but sound, for it rests almost entirely on the evidence of a single manuscript, which is an unfaithful copy of a faulty and defective archetype.² Consequently the conditions in Ammianus are well-nigh the worst possible. This will prevent us from attaining to certainty upon one or two points of his usage, which, however, are of relatively slight import.³ Owing to the uniformity (not to say monotony) of his rhythm, all its essential features present themselves with distinctness even in our imperfect text.

So great is this uniformity that I have considered it unnecessary to demonstrate my observations by statistical evidence based on the full text of Ammianus. It goes without saying, of course, that I have confirmed them, both in general tenor and in certain particulars, by repeated readings of the Histories, but the statistics which I shall adduce in proof of them are not imposing. They rest upon two distinct bases which include less than 3300 clausulae. One of these is a catalogue of all the sentence-endings (exclusive of direct quotations) in the first six and the last three books of our author, amounting in all to 1811. The making of this collection was the first step in my investigation, and in restricting it to sentence-endings I was naturally determined by the fact that here if anywhere the clausula is certain to occur. But, the final cadences once fixed, those in the interior of the sentence could not be left out of account: hence the second collection, which embraces *all* the clausulae in Book XXI, numbering 1461.

The results of my investigation fall under two heads: first, the character of the rhythm in Ammianus, and second, inferences drawn from the rhythm. Under the first head we shall consider first the nature of the clausulae employed by Ammianus (taking up in order the forms, the types and the matter of residual quantity, and closing with a brief study of their origin), and next the manner of their employment (length of kola, number of kola in sentence, structure of sentence, responson, etc.). Under the second head fall two groups of observations—those pertaining to linguistic phenomena (matters

¹ *Rhythmen d. asian. u. röm. Kunstprosa*, p. 123.

² Vat. Lat. 1873 (17). Gelenius' edition contains some readings from a Hersfeld codex, since lost. This, though it is apparently independent of *V*, is unquestionably a copy of the same archetype. On these matters see C. U. Clark, *The Text Tradition of Amm. Marc.*, New Haven, 1904.

³ The question whether he absolutely avoided the clausula A (v. p. 175), and the cadence I made in a single word (v. p. 185).

of accent and syllabication) and those of a critical nature (dealing both with text criticism and the higher criticism). Some of the facts presented in this second part are of a nature to arouse interest even among those who stand aloof from the field of rhythmical studies.

Not only with the idea of facilitating control of my statements, but with the larger purpose of presenting a clear and intelligible picture of Ammianus' rhythm, I shall introduce my discussion of the subject by printing Book XXI in full, sundering the kola from one another and marking the form and type of each clausula.

AMMIANI MARCELLINI RERUM GESTARUM LIBER XXI.

Preliminary Note.

No motive of any significance underlies my choice of Book XXI for analysis. Any other portion of the Histories would have yielded similar results, and I took this particular book because it seemed to have a fairly sound text and had not previously been worked over for my collection of sentence-endings. Gardhausen's text is taken as a basis; variations from it are accounted for in the footnotes. As my object is not so much to edit the text as to edit the rhythm of it, I have made few changes except in the clausula. Here I have admitted conjectures with considerable freedom, but the reader will note that in most instances they do not rest solely upon metrical grounds. The evidence of the unamended text will be considered later.

Though in general the text is so arranged as to give each kolon a separate line, I have occasionally printed two or more on one line without any definite system save an inclination to do so in the case of short kola (or kommata) that respond. The numbering of the forms has already been explained: the Greek letters that distinguish the types of the different forms are interpreted fully on page 178. The sign 7 marks the end of a cadence which is probably accidental, though the distinction is sometimes difficult to make.¹ Where the accent or syllabication of a word is peculiar I have marked it in the usual way, and on the first occurrence of each phenomenon I have referred to the place where it is treated in the chapter dealing with matters of pronunciation. In order to interpret the clausulae readily the reader should note in advance that elision does not occur in Ammianus, while hiatus (within certain bounds) is frequent (p. 222); further, that it makes no difference whether a word-break does or does not precede the first accented syllable of the cadence (p. 181).

¹ The question of accidental clausulae is treated on p. 205f.

- (I. 1) Intercluso hac bellorum difficili sorte Constantio II γ
trans flumen Euphratem, I γ
Iulianus agens apud Viennam I γ
formandis in futura consiliis II γ
5 dies inpendebat et noctes, I γ δ
quantum opes patiebantur angustae I γ
altius semet adtollens, I γ
semperquē ambigens II δ
utrum Constantium 7 modis omnibus alliceret
in concordiam IV δ ϵ
10 an terroris incutiendi gratia lacesseret prior. I δ
(2) quae sollicite reputans utrumquē formidabat, II δ III δ
et amicum cruentum I γ
et (inimicum) in aerumnis civilibus saepe vic-
torem; I γ
maximeque Galli fratris exemplum I γ
15 mentem eius anxiam suspendebat, III δ
quem inertia mixtaeque periuriis fraudes pro-
didere quorundam. I γ
(3) erigebat tamen aliquotiens animum II δ
ad multa [et] urgentia, (II γ)
tutissimum ratus I δ
20 inimicum se ex confesso monstrare I γ
ei cuius ex praeteritis motus I δ
coniectabat ut prudens, I γ δ
ne per amicitias fictas insidiis falleretur occultis. I δ I γ
(4) parvi igitur habitis II δ
25 quae per Leonam Constantius scripserat, II δ
nulloque arbitrio eius promotorum suscepto 7
praeter Nebridium, II γ
quinquennalia Augustus iam edidit: II γ δ
et ambitioso diademati utebatur III δ
lapidum fulgore distincto, I γ
30 cum inter exordia principatus adsumpti I γ
vili corona circumdatus II γ
erat xystarchae similis purpurato. III δ
(5) inter quae Helenae coniugis defunctae suprema I γ
miserat Romam I δ

8 quē *semivocalis u* apud Ammianum syllabam saepe facit: v. p. 226

13 inimicum *addidi* 18 et *delevi non modo metro sed sensui obnoxium*:

v. p. 171

	in suburbano viae Noëmentanae condenda,	I γ
	ubi uxor quoque Galli quondam, soror eius, se-	
	pulta est Constantina.	III γδ
(6)	accedebat autem incendebatque eius cupiditatem	III γ
	pacatis iam Galliis incessere ultro Constantium	II γδ II γ
5	coniciens eum 7	
	per vaticinandi praesagia multa 7 quae callebat	
	et somnia	II γδ
	e vita protinus excessurum.	III δ
(7)	et quoniam erudito et studioso cognitionum	
	omnium principi	II δ
	malivoli praenoscendi futura	I γ
10	pravas artes adsignant,	I γ
	advertendum est breviter	II γδ
	unde sapienti viro hoc quoque accidere poterit,	II δ
	doctrinae genus haud leve.	I γδ
(8)	elementorum omnium spiritus	II δ
15	utpote perennium corporum	II δ
	praesentiendi motu semper et ubique vicens	I δ
	ex his quae per disciplinas varias adfectamus	III δ
	participat nobiscum munera divinandī:	III δ
	et substantiales potestates ritu diverso placatae	I γ
20	velut ex perpetuis fontium venis	I δ
	vaticina mortalitati suppeditant verba,	I δ
	quibus numen praeesse dicitur Themidis,	II δ
	quam ex eo quod fixa fatali lege decreta	I γ
	praescire facit in posterum,	II γδ
25	quae <i>τεθρημέρα</i> sermo Graecus appellat,	I β I γ
	ita cognominatam	III γ
	in cubili solioque Iovis vigoris vivifici	II γ
	theologi veteres conlocarunt.	III δ
(9)	auguria et auspicia	IV δε
30	non volucrum arbitrio futura nescientium conli-	
	guntur—	III δ
	nec enim hoc vel insipiens quisquam dicet—	I δ
	sed volatus avium dirigit deus	I δ
	ut rostrum sonans aut praetervolans pinna	I δ
	turbido meatu vel leni	I γδ
35	futura praemonstret.	I γ
	amat enim benignitas numinis,	II δ
	seu quod merentur homines seu quod tangitur	
	eorum adfectione,	III γ

- his quoque artibus prodere quae inpendent. III δε
 (10) extis itidem pecudum attentis fatidicis, II γ
 in species converti suetis innumeras, II γ
 accidentia sciunt. I δ
 5 cuius disciplinae Tages nomine quidam mon-
 strator est, II γζ
 ut fabulantur, in Etruriae partibus II δ
 emersisse subito visus e terra. I γδ
 (11) aperiunt tunc quoque ventura I γ
 cum aestuant hominum corda I δ
 10 (sed locuntur divina). I γ
 sol enim, ut aūnt physici, II δ
 mens mundi nostras mentes ex sese 7 velut
 scintillas diffunditans, II γ
 cum eas incenderit vehementius IV δ
 futuri conscias reddit; I δ
 15 unde Sibyllae crebro se dicunt ardere I γ
 torrente vi magna flammaram. I γ
 multa significant super his crepitus vocum I δ
 et occurrentia signa, I δ
 tonitrua quin etiam et fulgura et fulmina itidemque
 siderum sulci. I δ
 (12) 20 somniorum autem rata fides et indubitabilis foret, I δ
 ni ratiocinantes coniectura fallerentur interdum. (I γ)
 quae, ut Aristotéles adfirmat, I γ
 tum fixa sunt et stabilia, IV γδε
 cum animantis altius quiescentis ocularis pupilla III δ I γ
 25 neutrubi inclinata rectissime cernit. III δ I δ
 (13) et quia vanities aliquotiens plebeia strepit, I δ
 haec inperite mussando, I γ
 si esset praesentiendi notitia quaedam, I δ
 cur ille se casurum in bello I γδ
 30 vel alius hoc se passurum ignoravit aut illud, I βγ I γδ
 sufficere dici I δ
 quod et grammaticus locutus interdum est barbaramente II γδ
 et absurde cecinit musicus II δ
 et ignoravit remedium medicus: II δ
 35 at non ideo nec grammatica nec musica nec
 medicina subsistit. I γ
 (14) unde praeclare hoc quoque ut alia II γδ

11 aūnt *v. p. 224* 21 fallerentur interdum quae *Bentleius, Madvig* fallerentur.
 interdumque *edd. v. p. 171* 22 Aristotéles *v. p. 214* 26 plebeia *v. p. 224*

	Tullius 'signa ostenduntur' ait 'a dis rerum futurarum	[A]
	in his siqui erraverit	[II γ]
	non deorum natura	[I γ]
	sed hominum coniectura peccavit.'	[I γ]
5	ne igitur extra calcem, quod dicitur, sermo decurrens	I γ
	lecturo fastidium ferat,	I δ
	ad explicanda proposita revertamur.	(III δ)
(II. 1)	cum apud Parisios adhuc Caesar Iulianus quatiens scutum	I δ
	variis motibus 7 exercebatur in campo,	I γδ
10	axiculis quibus orbis erat conpaginatus in vanum excussis,	I γ
	ampla remanserat sola	I δ
	quam retinens valida manu stringebat;	I γ
(2)	territisque ut omine diro praesentibus cunctis, 'nemo' inquit 'vereatur:	I δ I δ III δ
15	habeo firmiter quod tenebam.'	III δε
	item cum apud Viennam postea quiesceret sobrius,	II δ
	horrore medio noctis	I δ
	imago quaedam visa splendidior	II γ
	hos ei versus heroos	I γ
20	módo non vigilantibus	III γδ
	aperte dixit eadem saepius replicando,	III δ
	quibus fretus nihil asperum sibi superesse exi- stimabat.	III γ
	<i>(quattuor versus Graecos omisi)</i>	
(3)	agebat itaque nihil interim de statu rerum praesentium mutans,	I δ
	sed animo tranquillo et quieto	III γδ
25	incidentia cuncta disponens,	I γ
	paulatimque sese corroborans	II γ
	ut dignitatis augmento	I γ
	virium quoque congruerent incrementa.	III δ
(4)	utque omnes nullo impediante	III γ
30	ad sui favorem inliceret,	II γ
	adhaerere cultui Christiano fingebat,	I γ

1 Cic. de nat. deor. II 4. 12 ubi erraverunt: v. p. 242 7 proposita
Kellerbauer prospecta V. v. p. 171; 176 10 quibus scripsi quis edd. quid V.
24 quieto v. p. 227.

	a quo iam pridem occulte desciverat,	II γ
	arcanorum participibus paucis,	I δ
	haruspicinae auguriisque intentus	I γ
	et ceteris quae deorum semper fecere cultores.	I γ
5	et ut haec interim celarentur,	III δ
(5)	feriarum die quem celebrantes mense Ianuario	
	Christiani	III δ
	Epiphánia dictitant	II δ
	progressus in eorum ecclésiam	II γ
	sollemniter numino orato discessit.	I γ
(III. 1) 10	dum haec ita aguntur	I γ
	propinquante iam vere,	I γ δ
	nuntio percitus inopino	III δ
	ad tristitiam versus est et maerorem:	III γ δ ε
	didicit enim Alamannos a pago Vadomari exorsos,	(I γ)
15	unde nihil post ictum foedus sperabatur incom-	
	modum,	II γ
	vastare confinis Raetiis tractus,	I δ
	nihilque sinere intemptatum	III δ
	manus praedatorias fusius discurrentes.	III δ
(2)	quod ne dissimulatum redivivas bellorum materias	
	excitaret,	III δ
20	Libinonem quendam comitem cum Celtis et	
	Petulantibus misit	I δ
	hiemantibus secum,	I δ
	negotium ut posebat ratio correcturum.	III δ
(3)	quicum mature prope oppidum Sanctionem venisset	I γ
	longe visus a barbaris,	II γ δ
25	qui iam certamina meditantés	III δ
	sese per valles abdiderant,	II γ
	hortatusque milites licet numero in pares	II δ
	cupidine tamen pugnandi 7 vehementius iritatos,	III δ
	adgreditur inconsulte Germanos,	I γ
30	interque dimicandi exordia	II γ
	ipse concidit omnium primus:	I δ
	cuius interitu erecta barbarorum fiducia	II γ
	Romanisque ad ducis vindictam accensis	I γ
	certamen committitur obstinatum,	III δ
35	et urgente magnitudinis mole disiecti sunt nostri	I δ I γ δ

7 Epiphania τ. p. 212

14 Vadomarii V et edd. (τ. p. 233)

18 post manus perperam interpunxit Gardl.

	occisis paucis et vulneratis.	III γδ
(4)	cum hoc Vadomario et Gundomado eius fratre itidem rege	I δ
	Constantius, ut iam relatum est, firmaverat pacem.	I δ
	post quae mortuo Gundomádo	III δ
5	hunc sibi fore existimans fidum	I δ
	secretorumque taciturnum exsecutorem et effi- cacem,	III γδ
	mandabat, si famae solius admittenda est fides,	I γ I γδ
	scribebatque ut tamquam rupto concordiae pacto	I δ
	subinde conlimitia sibi vicina vexaret,	I γ
10	quo Iulianus id metuens	II γδ
	nusquam a tutela discederet Galliarum.	III δ
(5)	quibus, ut dignum est credere,	II γδ
	obtemperans Vadomarius	IV δ
	haec et similia perpetrabat,	III δ
15	ad perstringendum fallendumque miris modis ab aetatis primitiis callens,	I δ
	ut postea quoque ducatum per Phoenicem regens ostendit.	I γ
	sed re ipsa convictus abstinuit;	II γ
	capto enim a stationariis militibus notario quem miserat ad Constantium,	IV δ ε
	scrutatoque siquid portaret,	I γ
20	epistula eius reperta est	II γ ζ
	in qua praeter alia multa	I δ
	id quoque scripserat,	II δ
	'Caesar tuus disciplinam non habet.'	I γ δ
	Iulianum autem adsidue per litteras dominum et Augustum	III δ ε
25	appellabat et deum.	I γ δ
(IV. 1)	haec ut erant periculosa et dubia, Iulianus,	III δ
	in exitiale malum eruptura considerans,	II γ
	in unum omni cogitatione intenta,	I γ
	eum incautum rapere festinabat,	III δ
30	ut securitatem suam provinciarumque locaret in tuto;	I γ δ
	et iniit consilium tale.	I δ
(2)	Philagrium notarium, orientis postea comitem,	II δ
	ad eas miserat partes	I δ

	cuius prudentiæ fidebat olim sibi conperiti,	I γ I γ
	eique inter multa quae pro captu instantium	
	rerum erat acturus	I δ I γ
	signatam quoque chartulam tradidit,	II δ
	mandavitque ne aperiret vel recitaret	III γ δ
5	nisi Vadomario viso cis Rhenum.	I γ δ
(3)	perrexit Philagrius ut praeceptum est,	IV δ ε θ
	eoque praesente et negotiis adstricto diversis	I γ I γ
	transgressus Vadomarius flumen	I δ
	ut nihil in profunda metuens pace	I δ
10	nihilque secus gestorum 7 simulans scire,	I δ
	viso praeposito militum ibi degentium.	II γ
	pauca locutus ex more,	I γ δ
	ultro semet, ut suspicionis nihil relinqueret abi-	
	turus,	III δ
	ad convivium eius venire promisit,	I γ
15	ad quod erat etiam Philagrius invitatus.	III δ
(4)	qui statim ingressus rege conspecto	I γ I γ
	imperatoris recordatus est verba;	I γ δ
	causatusque rem seriam et urgentem	III δ ε
	ad diversorium redit, scriptisque lectis	(I δ) I δ
20	doctus quid agi conveniet	(II γ)
	confestim reversus discubuit inter ceteros.	I γ IV δ ζ
(5)	finitisque epulis 7 Vadomarium fortiter adpre-	
	hensum	III δ
	rectori militum arte custodiendum apud signa	
	comisit,	I γ
	textu lecto iussorum,	I γ
25	comitibus eius ad sua redire compulsis,	I γ
	super quibus nihil fuerat imperatum.	III δ
(6)	exhibitus tamen idem rex ad principis castra,	I δ
	iamque spe veniae omni praeclusa	I γ
	cum interceptum notarium	II γ
30	et quae scripserat ad Constantium	IV δ ε
	comperisset iam publicata,	III γ δ
	ne convicio quidem tenus compellatus missus	
	est ad Hispanias.	IV γ δ ε
	id enim studio curabatur ingenti	I γ
	ne Iuliano discedente a Galliis	II γ δ

1 prudentiæ v. p. 223 sq.

19 redit scripsi rediit edd., v. p. 211

20 conveniet V, conveniret edd., v. p. 171

	inmanissimus homo 7 provinciarum statum aegre compositum	II γ
	licentius conturbaret.	III δ
(7)	hoc casu elatior Iulianus	III δ
	regis opinione citius intercepti	III δ
5	quem profecturus ad longinquā formidabat,	III δ
	nihil remittentibus curis	I δ
	barbaros adoriri disposuit	II γ
	quos peremisse Libinonem comitem	(II δ)
	in congressu cum militibus docuimus paucis.	I δ
(8) 10	et ne rumor adventus sui eos ad remotiora traduceret,	II γ
	superato Rheno noctis alto silentio	II γ
	cum auxiliorum expeditissimis globis	I δ
	nihil metuentes huiusmodi circumvenit,	III δ
	excitatosque hostilium fragore armorum	I γ
15	dum gladios circumspectant et tela	I γ δ
	celeriter involavit:	III δ
	et quosdam occidit,	I γ
	orantes alios praedamque offerentes dediticios cepit,	I δ
	reliquis qui remansere pacem precantibus dedit,	I δ
20	quietem pollicitis firmam.	I δ
(V. 1)	quae dum mentibus aguntur erectis,	I γ
	coniectans quantas intestinae cladis excitaverat moles,	I δ
	nihilque tam convenire conatibus subitis 7 quam celeritatem	I α?
	sagaci praevidens mente,	I δ
25	professa palam defectione	III γ
	se tutiorem fore existimavit,	III γ
	incertusque de militum fide,	I δ
	placata ritu secretiore Bellona,	I γ
	classico ad contionem exercitu convocato,	III δ
30	saxeo suggestu insistens,	I γ
	iamque, ut apparebat, fidentior,	II γ
	haec clarius solito disserebat:	III δ
	(<i>adhortatio Iuliani</i>)	
(2)	iam dudum tacita deliberatione vos aestimo,	II γ δ

	magni conmiliones,	III γ
	gestorum excitos amplitudine,	IV δ
	hoc operari consilium	II γ
	ut eventus qui sperantur perpendi possint et praecaveri:	III γ δ
5	plus enim audire quam loqui militem decet	I δ I δ
	actibus coalitum . . . gloriosis,	(III δ)
	nec alia spectatae aequitatis sentire rectorem	I γ
	quam ea quae laudari digne poterunt et probari.	(III δ ε)
	ut igitur quae proposui abiectis . . . absolvam	(I γ)
10	advertite oro benivole	II γ
	quae sermone brevi percurram.	I γ
(3)	arbitrio dei caelestis	I γ
	vobis inter ipsa iuventae rudimenta permixtus	I γ
	inruptiones Alamannorum adsiduas et Francorum	III δ ε
15	populandique iugem licentiam fregi,	I δ
	et vigore communi Romanis agminibus	I γ II γ
	quotiens libet Rhenum pervium feci,	I δ I δ
	contra rumorum fremitus gentiumque validarum violentos excursus	I γ
	stando immobilis	II γ
20	virtutis vestrae nimirum firmamento confisus.	I γ
(4)	et haec laborum quos exhausimus Galliae spec- tatrices	III δ
	post funera multa 7 iacturasque recreatae diutur- nas et graves	I γ δ
	posteritati per aetatum examina commendabunt.	III δ
(5)	at nunc cum auctoritate vestri iudicii	II γ
25	rerumque necessitate compulsus	I γ
	ad augustum elatus sum culmen,	I γ δ
	deo vobisque fautoribus,	II γ
	si fortuna coeptis adfuerit,	II γ
	altius adfecto maiora,	I γ
30	id prae me ferens	I γ γ δ
	quod exercitui cuius aequitas armorumque in- claruit magnitudo	III δ
	domi moderatus visus sum et tranquillus,	III γ δ ε

6 *siquae exciderunt, fuisse conicio verba claris et, vel similia. Sed advertendum est verba coalitum gloriosis clausulam explere* 8 poterunt Haupt potuerunt V 9 abiectis V: lac. Eyssenh., Wagner abiectus sine lac. Gardt., Valesius. Fortasse abiectis nugis, nam ambagibus (Wagn.) pessime sonat.

	et in crebritate bellorum	I γ
	contra conspiratas gentium copias	II δ
	consideratus et cautus.	I γ δ
(6)	ut igitur adversa praeveniamus	III γ
5	mentium societate iunctissima,	II γ
	sequimini viam consilii mei	I δ
	salutarem ut puto,	I γ δ
	cum integritas rerum	I δ
	intentioni nostrae voluntatique respondeat,	II γ
10	et dum maioribus vacant praesidiis 7 regiones	
	Illyricae,	II γ
	inpraepedito cursu tendentes	I γ
	Daciarum interim fines extimos occupemus,	III δ
	exinde quid agi oporteat	II γ
	bonis successibus instruendi.	III δ
(7)	15 utque vos ex more fidentium ducam,	I δ
	iuramento quaeso concordiam spondete mansu-	
	ram et fidem	I γ δ
	operam mihi navaturo sedulam et sollicitam	(IV δ ε)
	nequid agatur inconsultum et segne,	I γ δ
	et producturo siquis exegerit incorruptam	III δ
20	conscientiam meam	I δ
	quod nihil voluntate praeter ea quae in com-	
	mune conducunt	I γ
	adgrediar aut temptabo.	III δ ε
(8)	illud sane obtestor et rogo,	I γ δ
	observate ne impetu gliscentis ardoris	I γ
25	in privatorum damna quisquam vestrum exiliat,	II γ
	id cogitans quod ⟨haud⟩ ita nos inlustrabunt	
	hostium innumerae strages	I δ
	ut indemnitas provinciarum et salus	I γ δ
	exemplis virtutum pervulgatae.	*A
	(<i>finis adhortationis</i>)	
(9)	hoc sermone imperatoris 7 vice alicuius oraculi	
	conprobato	III δ
30	mota est incitatus contio,	II δ
	et rerum cupida novandarum	III δ

15 utque vos *Petschenig* (*Philol.* 50, p. 348) ut quos V ducam *Petschenig*
ducum V 17 sollicitam *C. F. W. Müller, Kiessling, Löfstedt*
sollitam V 25 *fortasse enuntiandum exiliat, ut primam efficias formam*
26 *haud inser. Valesius inlustrabunt Petschenig (Phil. 50. 348)* 28 per-
vulgatae virtutum *legendum esse censeo*

	unanimanti consensu voces horrendas	I γ I γ
	immani scutorum fragore miscebat,	I γ
	magnum elatumque ducem	I δ
	et ut experta est fortunatum	III γ δ
5	domitorem gentium adpellans et regum.	I γ δ
(10)	iussique universi in eius nomen iurare sollemniter,	II γ
	gladiis cervicibus suis admotis	I γ
	subexsecrationibus diris verbis iuravere conceptis	I δ I γ
	omnes pro eo casus quoad vitam profuderint	II γ
10	si id necessitas exegerit perlaturus:	III δ
	quae secuti rectores omnesque principis proximi	II δ
	fidem simili religione firmarunt.	I γ
(11)	solus omnium licet proposito stabili	II δ
	audacter tamen praefectus repugnavit Nebridius,	II γ
15	iuris iurandi nexu contra Constantium	II γ
	nequaquam se constringi posse commemorans,	II γ
	cuius beneficiis obligatus erat crebris et multis.	I γ δ
(12)	quibus auditis cum stantes propius milites	I γ II δ
	acriter inflammati eum adpeterent trucidandum	III δ III δ
20	ad genua sua prolapsum	I γ
	imperator paludamento protexit;	I γ
	indeque reversus in regiam,	II γ δ
	cum antegressum eum vidisset supplicemque	
	iacentem orare	I γ I γ
	ut levandi causa timoris ei porrigeret dexteram,	I γ II δ
25	'ecquid' ait 'praecipuum 7 amicis servabitur	II γ
	si tu manum tetigeris meam?	I δ
	sed hinc quo libet abi securus.'	I γ
	hocque audito	I γ
	ille innoxius ad larem suum recessit in Tusciam.	II γ II γ δ
(13) 30	his Iulianus ut posebat negotii magnitudo prae-	
	structis,	I γ
	expertus quid in rebus tumultuosis	III γ
	anteversio valeat et praegressus,	III δ ε
	per tesseram edicto itinere in Pannonias,	IV δ ε
	castris promotis et signis,	I γ δ
35	temere se fortunae commisit ambiguae.	II γ
(VI. 1)	replicare nunc convenit tempora	II δ
	et narrare summatim	I γ
	quae, dum aguntur in Galliis antedicta, Constantius	II γ

	hiemans Antióchiaē	IV δ
	domi militiaeque perfecit.	I γ
	inter conplures alios honore conspicuos	II γ
	adoraturi imperatorem peregre venientem	III γ III δ
5	ordinantur etiam extribunis insignibus.	II γ
(2)	cum igitur a Mesopotamia reversus Constantius	II γ
	hoc exciperetur officio,	II γ
	Amphilochius quidam extribuno	A ?
	Paphlago quem dudum sub Constante militantem	A ?
10	discordiarum sevisse causas	C ?
	inter primores fratres	C ?
	suspiciones contiguae veritati pulsabant,	I γ
	ausus paulo petulantius stare	I δ
	ut ipse quoque ad parile obsequium admittendus	III δ
15	agnitus est et prohibitus,	II β γ
	strepentibusque multis	I δ
	et intueri lucem ulterius non debere clamantibus	II γ
	ut perduellem et obstinatum,	III γ δ
	Constantius circa haec lenior solito	II δ
20	'desinite' ait 'urgere	I γ
	hominem ut existimo sontem	I γ
	sed nondum aperte convictum:	I γ
	et mementote quod siquid admisit huiusmodi	II γ
	sub obtutibus meis	I δ
25	conscientiae ipsius sententia punietur,	III δ
	quam latere non poterit,	II γ δ
	et ita discessum est.	II γ ζ
(3)	postridie ludis Circensibus idem	I δ
	ex adverso imperatoris ubi consueverat spectans,	I δ
30	repentino clamore sublato	I γ
	cum certamen opinatum emitteretur,	III γ
	diffRACTIS cancellis	I γ
	quibus una cum pluribus incumbibat,	III δ
	cunctis cum eo in vanum excussis	I γ
35	laesisque leviter paucis,	I δ
	interna conpage disrupta	I γ
	efflase spiritum repertus (est) solus,	(I γ δ)
	unde Constantius futurorum quoque praescius	
	exultabat.	III δ

1 Antióchiaē v. p. 212
autem sit sanandus haereo. v. p. 171

8 s. hunc locum mendosum esse credo: quomodo
37 est Accursium secutus addidi

- (4) eodem tempore Faustinam nomine sortitus est
 coniugem, II γ δ
 amissa iam pridem Eusebia, II γ
 cuius fratres erant Eusebius et Hypatius consulares, III δ
 corporis morumque pulchritudine 7 pluribus
 antistante III δ
 5 et in culmine tam celso humana, I γ
 cuius favore iustissimo II γ
 exemptum periculis declaratumque Caesarem II γ II δ
 rettulimus Iulianum. III δ
- (5) habita est isdem diebus etiam Florentii ratio II δ
 10 e Galliis novitatis metu digressi, I γ
 et Anatólio recens mortuo IV δ ζ
 praefecto praetorio per Illyricum IV δ ε
 ad eius mittitur locum, I δ
 cumque Tauro itidem praefecto praetorio per
 Italiam IV δ ε
 15 amplissimi suscepit insignia magistratus. III δ
- (6) parabantur nihilominus externorum atque civilium
 instrumenta bellorum, I γ
 et augebatur turmarum equestrium numerus II δ
 parique studio supplementa legionibus scripta sunt II δ ζ
 indictis per provinciam tirociniis, IV δ
 20 omnisque ordo et professio vexabatur, III δ
 vestem armaque exhibens et tormenta, III δ ε
 aurum quin etiam et argentum, III δ ε
 multiplicisque rei cibariae copias II δ
 et diversa genera iumentorum. III δ
- (7) 25 et quia Persarum rege ob difficultatem hiberni
 temporis aegre contruso I γ
 reserata caeli temperie II γ
 validior impetus timebatur, III δ
 ad Transtigritanos reges et sátrapas II γ δ
 legati cum muneribus missi sunt amplis, I γ δ
 30 monituri cunctos et hortaturi III γ δ
 nostra sentire I γ
 et nihil fallax temptare vel fraudulentum. III γ δ
- (8) ante omnia tamen Arsáces et Meribánes, III γ δ
 Armeniae et Hiberiae reges, I δ
 35 cultu ambitioso indumentorum emercabantur III γ

	et multiformibus donis,	I δ
	damna negotiis inlaturo Romanis	(I γ)
	si rebus tum etiam dubiis	II δ
	descivissent ad Persas.	I γ δ
(9)	5 inter tot urgentia Hermogène defuncto,	I γ
	ad praefecturam promovetur Helpidius,	II γ
	ortus in Paphlagonia,	IV γ δ
	aspectu vilis et lingua,	I γ δ
	sed simplicioris ingenii, incruentus et mitis,	II γ I γ δ
10	adeo ut cum ei coram innocentem quandam	
	torquere	I γ
	Constantius praecepisset,	III δ
	aequo animo abrogari sibi potestatem oraret,	I γ
	haecque potioribus aliis	II δ
	ex sententia principis 7 agenda permitti.	I γ
(VII. 1)	15 rigore itaque instantium negotiorum anceps	
	Constantius	II γ
	quid capesseret ambigebat,	III δ
	diu multumque anxius	II δ
	utrum Iulianum peteret et longinqua,	III δ ε
	an Parthos repelleret	II γ
20	iam transituros ut minabantur Euphratem,	I γ
	haerensque tandem,	I δ
	cum ducibus communicato saepe consilio,	II γ
	in id flexus est ut finito propiore bello vel certe	
	mollito,	I γ
	nullo post terga relicto quem formidaret,	III γ δ
25	Illyriis percursis et Italia, ut rebatur,	III δ ε
	Iulianum inter exordia ipsa coeptorum	I γ
	tamquam venaticiam praedam caperet.	IV δ ζ (?)
	hoc enim ad leniendum suorum metum subinde	
	praedicabat.	III δ
(2)	tamen ne intepesceret	III γ δ
30	aut omisisse belli videretur aliud latus	I δ
	adventus sui terrorem ubique dispergens,	I γ I γ
	veritusque ne Africa absente eo perumperetur,	III γ
	ad omnes casus principibus oportuna,	III δ
	velut finibus orientis egressus	I γ

2 Romanis inlaturo *V. transposui*
claudendi genus insolitum; v. p. 184.
scribe caperet praedam

27 venaticiam praedam caperet
Ut cadat melius, verbis transpositis

28 subinde *v. p. 208*

	per mare notarium misit Gaudentium	II γ
	quem exploratorem actuum Iuliani per Gallias	II γ δ
	aliquamdiu fuisse praestrinximus.	II γ
(3)	hunc enim obsequio celeri cuncta	I δ
	5 consideratione gemina efficere posse sperabat	I γ
	quod adversam partem metuet ut offensam	(III δ ε)
ε	et properabit nactus hanc oportunitatem com-	
	mendari Constantio	II γ
	quem credebat procul dubio fore victorem :	I γ
	nemo enim omnium tunc ab hac constanti	
	sententia discrepat.	III δ
(4)	10 qui cum eo venisset	I γ
	mandatorum principis memor,	I δ
	per litteras Cretione comite quid ageretur edocto	I γ
	reliquisque rectoribus,	II γ
	lecto undique milite fortiore	III δ
	15 translatisque ab utraque Mauritania discursatoribus	
	expeditis	III δ
	Aquitaniae et Italiae obiecta litora tuebatur artissime.	II γ
(5)	neque id consilium fefellit Constantium :	II γ
	eo enim superstite	II γ
	nullus adversorum illas tetigit terras,	I δ
	20 licet oram Siciliensem	III γ
	a Lilybaeo protentam ad Páchynum	II γ δ
	multitudo servabat armata,	I γ
	si patuisset facultas	I γ
	ocius transitura.	III δ
(6)	25 his pro rerum ratione ut sibi prodesse existimabat	
	Constantius	II γ
	aliisque minutis et levioribus ordinatis,	III δ
	ducum nuntiis docebatur et litteris	II γ δ
	Persarum copias in unum coactas	I γ
	rege turgido praeunte	III δ
	30 iam prope margines tendere Tigridis,	II δ
	incertum quonam erumpere cogitantes.	III δ
(7)	quibus percitus ut propius agens	I δ
	futuros possit antevenire conatus,	I γ
	quam primum hibernis egressus,	I γ
	35 accito undique equitatu	III δ
	peditumque robore quo fidebat,	III δ ε
	per Capersanam Euphrate navali ponte transcurso	I γ

6 metuet ut *scripsi*; metueret *V v. p. 172*

21 Páchynum *v. p. 213*

	Édessam petit	I δ
	uberem com meatibus et munitam,	III δ ε
	ibi parumper operiens	II γ
	dum exploratores aut perfugae	II γ δ
	5 motum castrorum hostilium indicarent.	III δ
(VIII.1)	discedens inter haec Iulianus a Rauracis,	II γ δ
	peractis quae docuimus dudum,	I δ
	Sallustium praefectum promotum remisit in Gallias,	II γ δ
	Germaniano iusso vicem tueri Nebridii;	II γ
	10 itidemque Nevittae 7 magisterium commisit	
	armorum,	I γ
	Gumoarium proditorem antiquum timens,	I δ
	quem cum Scutarios ageret	II δ
	latenter prodidisse Veteranionem suum principem	
	audiebat,	III δ
	et Iovio quaesturam 7 cuius in actibus Magnenti	
	meminimus,	II γ
	15 et Mamertino largitiones curandas:	I γ
	et Dagalaifum praefecit domesticis,	II γ
	aliosque plures ex arbitrio suo 7 militibus re-	
	gendis adposuit	II γ
	quorum merita norat et fidem.	I γ δ
(2)	profecturus itaque per Marcianas silvas viasque	
	iunctas Histri fluminis ripis,	I δ
	20 inter subita vehementer incertus,	I γ
	id verebatur	I β
	ne contemptus ut comitantibus paucis	I δ
	multitudinem offenderet repugnantem,	III δ
(3)	quod ne fieret consilio sollerti praevidit:	I γ
	25 et agminibus distributis,	III δ
	per itinera Italiae nota	I δ
	quosdam properaturos cum Iovino misit et Iovio,	II γ δ
	alios per mediterranea Raetiarum	III δ
	magistro equitum Nevittae commissos,	I γ
	30 quo diffusi per varia	II γ δ
	opinionem numeri praeberent immensi	I γ
	formidineque cuncta conplerent.	I γ
	id enim et Aléxander Magnus	I δ
	et deinde alii plures	I δ
	35 negotio ita poscente periti fecere ductores.	I γ I γ

(4)	mandabat tamen egressis	I γ
	ut tamquam hoste protinus occursuro	III δ
	tutius graderentur,	III δ
	stationesque nocturnas 7 agerent et vigalias	IV δ ε
5	ne improvise hostium invaderentur excursu.	I γ
(IX. 1)	quibus ita, ut videbatur, apte dispositis,	II γ
	more quo tractus perruperat saepe barbaricos,	II γ
	contextis successibus fidens	I δ
	porrectius ire pergebat,	I γ
(2) 10	cumque ad locum venisset	I γ
	unde navigari posse didicit flumen,	I δ
	lembis escensis	I γ
	quos oportune fors dederat plurimos	II δ
	per alveum quantum fieri potuit	II δ
15	ferebatur occulte;	I γ
	ideo latens	I δ
	quod toleranter et fortiter	II γ δ
	nullius cibi indigens mundioris	III δ
	sed paucis contentus et vilibus	II γ δ
20	oppida forinsecus transibat et castra,	I γ δ
	imitatus egregium illud Cyri veteris dictum	I δ
	qui cum delatus ad hospitem	II γ δ
	interrogaretur ab eo	I γ δ
	quid ad convivium parari deberet,	I γ
25	panem responderat solum;	I δ
	sperare enim aiebat 7 prope rivum se cenaturum.	III γ δ
(3)	fama vero, quae mille ut aiunt linguis	I δ
	rerum mire exaggerat fidem,	I δ
	per Illyrios omnes celebrior fundebatur,	III δ
30	Iulianum strata per Gallias multitudine regum	
	et gentium	II γ δ
	numero exercitu	II γ
	et successibus tumidum variis adventare.	III δ
(4)	quo rumore perculsus	I γ
	praefectus praetorio Taurus	I δ
35	ut hostem vitans externum mature discessit,	I γ I γ
	vectusque mutatione celeri cursus publici transitis	
	Alpibus Iuliis	II δ
	eodem ictu Florentium 7 itidem praefectum	
	secum abduxit,	I γ
(5)	levibus tamen indicis 7 super Iuliani motu	
	Lucillianus percitus comes	I δ

	qui per illas regiones rem curabat ea tempestate	
	castrensem,	I γ
	agensque apud Sirmium	IV δ ε
	milites congregans	II δ
	quos ex stationibus propriis acciri celeritatis ratio	
	permittebat,	III δ
	5 venturo resistere cogitabat.	III δ
(6)	sed ille ut fax vel incensus malleolus	II γ
	volucriter ad destinata festinans,	I γ
	cum venisset Bononeam	II γ
	a Sirmio miliario nono disparatam et decimo,	II γ δ
10	senescente luna ideoque obscurante noctis ma-	
	ximam partem,	I δ
	e navi exiluit improvisus:	III δ
	statimque Dagalaifum misit cum expeditis	III γ δ
	ad Lucillianum vocandum	I γ
	trahendumque si reniteretur,	(V ?)
(7)	15 qui tum etiam quiescens	III δ
	cum strepitu excitatus turbulento vidisset	I γ
	ignotorum hominum se circulo circumsaeptum,	III δ
	concepto negotio	II γ
	et imperatorii nominis metu praestricus	I γ
20	praeceptis paruit invitissimus:	IV δ
	secutusque alienum arbitrium	II γ
	magister equitum paulo ante superbus et ferox,	I γ δ
	iumentoque inpositus repentino,	III δ
	principi ut captivus offertur ignobilis	II γ
25	oppressam terrore vix colligens mentem.	I δ
(8)	verum cum primitus visus	I δ
	adorandae purpurae datam sibi copiam advertisset,	III δ
	recreatus tandem sui que securus	I γ
	' incaute ' inquit ' imperator et temere	II γ δ
30	cum paucis alienis partibus te commisisti.'	I β
	cui amarum Iulianus subridens	I γ
	' haec verba prudentia	II γ
	serva ' inquit ' Constantio ;	II γ
	maiestatis enim insigne	I γ
35	non ut consiliario tibi	I δ
	sed ut desinas pavere porrexi.'	I γ

14 trahendumque *etc.* v. p. 169, *adn.* 1

15 quiescens v. p. 227

16 fortasse legendum est excitus turbulento (IIIδ), vidisset *etc.*

(X. 1)	nihil deinde amoto Lucilliano	III γ
	differendum nec agendum segnius ratus,	(I δ)
	ut erat in rebus trepidis audax et confidentior,	IV $\gamma \delta$
	civitatem ut praesumebat dediticiam petens	I δ
5	citis passibus incedebat :	III δ
	eumque suburbanis propinquantem 7 amplis ni-	
	mumque protentis	I γ
	militaris et omnis generis turba	I δ
	cum lumine multo et floribus	II $\gamma \delta$
	votisquæ faustis	I δ
10	Augustum adpellans et dominum	II $\gamma \delta$
	duxit in regiam.	II $\gamma \delta$
(2)	qui eventu laetus et omine,	II $\gamma \delta$
	firmata spe venturorum	III $\gamma \delta$
	quod ad exemplum urbium matris	I δ
15	populosae et celebris	II $\gamma \delta$
	per alias quoque civitates 7 ut sidus salutare	
	susciperetur,	III γ
	edito postridie curuli certamine 7 cum gaudio	
	plebis,	I δ
	ubi lux excanduit tertia	II δ
	morarum impatiens	II γ
20	percursis aggeribus publicis	II δ
	Succos nemine auso resistere	II γ
	praesidiis occupavit ;	III δ
	isdemque tuendis Nevittam praefecit ut fidum.	I γ I $\gamma \delta$
	cuius loci situm exnunc . . . conveniet et ostendi.	(III $\delta \epsilon$)
(3) 25	consertae celsorum montium summitates	III δ
	Haemi et Rhódopes,	II $\gamma \delta$
	quorum alter ab ipsis Histri marginibus	II γ
	alter ab Axii fluminis citeriore parte consurgit,	I γ
	in angustias tumulosis collibus desinentes	III δ
30	Illyrios interscindunt et Thracas,	I $\gamma \delta$
	hinc vicinae mediterraneis Dacis et Sêrdicae,	II $\gamma \delta$
	inde Thracias despectantes et Philippopolim,	IV $\gamma \delta$
	civitates amplas et nobiles :	II $\gamma \delta$
	et tamquam natura in dicionem Romanam 7 re-	
	digendas nationes circumscitas prae-	
	noscente	III δ

2 segnius ratus *Norák*, *Curæ Ammian*, *Pragae 1896* segne r. *Gardt*. *segem catus V* 24 *sine lac. V et om. Gardt.* *convenienter ostendam Eysseh. Forsitan exciderit describi vel simile quid*

	ita figuratae consulto,	I γ
	inter artos colles quondam hiantes obscurius,	II γ
	ad magnitudinem splendoremque postea rebus elatis	I γ
	patefactae sunt et carpentis,	III γ δ ε
5	aditibusque aliquotiens clausis	I δ
	magnorum ducum populorumque reppulere co- natus.	I γ
(4)	et pars quae Illyricum spectat mollius edita	I δ II δ
	velut incauta subinde superatur:	III δ
	latus vero e regione oppositum Thraciis	II δ
10	prona humilitate deruptum,	I γ
	hincque et inde fragosis tramitibus impeditum,	III δ
	difficile scanditur	II δ
	etiam nullo vetante.	I γ
	sub hac altitudine aggerum	II δ
15	utrubique spatiosa camporum planities iacet	I δ
	superior ad usque Iulias Alpes extenta,	I γ
	inferior ita resupina et panda	I γ δ
	ut nullis habitetur obstaculis	II γ
	adusque fretum et Propontidem.	III γ δ
(5) 20	his ut in re tali tanque urgenti conpositis,	II γ
	magistro equitum illic relicto,	I γ
	imperator revertitur Nāessum,	II δ
	copiosum oppidum quo inpraepedite cuncta dis- poneret	II γ
	suis utilitatibus profutura.	III δ
(6) 25	ubi Victorem apud Sirmium visum scriptorem historicum,	II γ
	exindeque venire praeceptum,	I γ
	Pannoniae secundae consularem praefecit,	I γ
	et honoravit aenea statua,	II δ
	virum sobrietatis gratia aemulandum,	III δ
30	multo post urbi praefectum.	I γ
(7)	iamque altius se extollens,	III δ ε
	et numquam credens ad concordiam provocari posse Constantium,	II γ
	orationem acrem et invectivam	III γ δ
	probra quaedam in eum explanantem et vitia	II γ δ
35	scripserat ad senatum.	III δ ε

	quae cum Tertullo administrante adhuc prae-	
	fecturam	I β
	recitarentur in curia,	II γ δ
	eminuit nobilitatis cum speciosa fiducia	II γ
	benignitas grata.	I δ
5	exclamatum est enim 7 in unum cunctorum sen-	
	tentia congruente,	III δ
	‘auctori tuo reverentiam rogamus.’	I γ
(8)	Tunc et memoriam Constantini ut novatoris	III γ δ
	turbatorisque priscarum legum et moris anti-	
	quitus recepti vexavit,	I γ
	eum aperte incusans	I γ
10	quod barbaros omnium primus	I δ
	ad usque fasces auxerat et trabeas consulares;	III δ
	insulse nimirum et leviter,	II γ δ
	qui cum vitare deberet	I γ
	id quod infestius obiurgavit,	III δ
15	brevi postea Mamertino 7 in consulatu iunxit	
	Nevittam,	I γ
	nec splendore nec usu nec gloria	II γ δ
	horum (cuiusquam) similem	(II δ)
	quibus magistratum amplissimum	II γ
	detulerat Constantinus:	III δ
20	contra inconsummatum et subagrestem,	III γ δ
	et (quod minus erat ferendum)	I γ
	celsa in potestate crudelem.	I γ
(XI. 1)	haec et talia cogitanti,	III δ
	sollicitoque super maximis rebus et seriis,	II γ δ
25	nuntius metuendus 7 intimatur et insperatus,	III γ δ
	ausa indicans quorundam immania,	II γ
	inpeditura cursus eius ardentis	I γ
	ni vigilanter haec quoque antequam adulescerent	
	hebetasset.	III δ
	quae breviter exponentur.	III δ
(2) 30	duas legiones Constantiâcas	(III γ)
	addita una sagittariorum cohorte,	I γ
	quas invenerat apud Sirmium,	IV δ ζ
	ut suspectae adhuc fidei	III γ ε
	per speciem necessitatum urgentium	II γ
35	misit in Gallias.	II γ δ

	quae pigrius motae,	I δ
	spatiaque itinerum longa	I δ
	et Germanos hostes truces et adsiduos formidantes,	III δ
	novare quaedam moliebantur,	III γ
5	auctore et incitatore Nigrino,	I γ
	equitum turmae tribuno	I γ
	in Mesopotamia genito:	II δ
	reque digesta per secreta colloquia	II γ
	et alto roborata silentio,	II γ
10	cum Aquileiam pervenissent,	III δ
	uberem situ et opibus	II γ δ
	murisque circumdatam validis,	II δ
	eam hostiliter repente clausere,	I γ
	iuvante indigena plebe tumultus horrorem,	I γ
15	cui Constanti nomen erat tum etiam amicum.	I γ ?
(3)	et obseratis aditibus,	II γ
	turribusque armatis et propugnaculis,	IV γ δ
	futurae concertationi praeparabant utilia,	II γ
	interim soluti et liberi:	II γ δ
20	hocque facinore ita audaci	I γ
	ad favendum Constanti partibus ut superstitis	IV δ ε
	Italicos incolas excitabant.	III δ
(XII. 1)	quibus Iulianus acceptis,	I γ
	agens tunc apud Naëssum	II β δ
25	nihil a tergo timens adversum,	I γ
	legensque et audiens	II γ δ
	hanc civitatem circumsessam quidem aliquotiens,	(IV δ ?)
	numquam tamen excisam aut deditam,	II γ δ
	impensiore studio sibi sociare vel fraude	I γ δ
30	vel diversis adulationum generibus	II γ
	antequam maius oriretur aliquid properabat.	III δ
(2)	ideoque Iovinum magistrum equitum venientem	
	per Alpes	I γ δ
	Noricosque ingressum,	I γ
	ad id quod exarserat quoquomodo corrigendum	III δ
35	redire citius imperavit.	III δ
	et nequid deesset,	I γ
	milites omnes qui comitatum sequebantur aut signa	I γ δ
	retineri iussit per idem oppidum transeuntes,	III δ

10 Aquileiam v. p. 224
initium V

25 an temnens?

15 amicum fortasse ἑντιμον: v. p. 208, n. 1
27 quidem aliquotiens v. p. 228 s.

	pro viribus laturos auxilium.	II γ
(3)	hisque dispositis,	II γ
	ipse haut diu postea cognita morte Constantii	II γ
	discursis Thraciis Constantinopolim introiit:	III δ
5	ac saepe doctus lentius fore id obsidium quam	
	verendum,	III δ ε
	Immo cum comitibus aliis ad hoc destinato	I β
	removit exinde Iovinum,	I γ
	alia quae potiores flagitabant necessitates acturum.	I γ
(4)	ordine itaque scutorum gemino Aquileia circum-	
	saepta,	III δ
10	concontinentibus sententiis ducum conveniens	
	visum est	I δ II δ ζ
	ad deditioem allicere defensores	III δ
	minacium blandorumque varietate sermonum:	I γ
	et multis ultro citroque dictitatis,	III δ
	in immensum obstinatione gliscente,	I γ
15	ex conloquio re infecta disceditur.	II γ
(5)	et quia nihil praeter pugnam iam sperabatur,	III γ δ
	curatis utrobique cibo somnoque corporibus,	II γ
	aurora iam surgente, concrepante sonitu buci-	
	norum,	III δ
	partes accensae 7 in clades mutuas ferocientes	
	magisquam consultius	II γ
20	elatis clamoribus ferebantur.	III δ
(6)	pluteos igitur praefereutes oppugnatores	III γ
	cratesque densius textas,	I δ
	sensim incedentes et caute,	I γ δ
	murorum ima suffodere	II γ
25	ferramentorum multitudine conabantur,	III δ
	factas plerique vehentes ad mensuram moenium	
	scalas;	I δ
	iamque parietibus paene contigui	II γ
	pars lapidibus volutis in pronum conlisi	I γ
	pars confixi stridentibus iaculis	II δ
30	retroque gradientes	III δ
	averterunt secum omnes alios metu similium 7	
	a proposito pugnandi detortos.	I γ

3 Constantii scripsi; Constanti V

7 exinde Iovinum v. p. 208

16 fortasse nil praeter pugnam (I) iam sperabatur (I) 19 magisquam

v. p. 207

- (7) hoc primo congressu erecti in audaciam clausi I γ I δ
 adsumpta fiducia meliorum III δ
 parvi ducebant restantia: II γ
 mentibusque fundatis I γ
 5 et compositis per oportuna tormentis I γ
 indefesso labore I γ
 vigiliis et cetera subsidia securitatis implebant. I γ
- (8) contra munitores licet pavore discriminum anxii, II δ
 pudore tamen ne socordes viderentur et segnes, I γ δ
 10 ubi parum vis procedebat I β
 Marte aperto temptata, I γ
 ad instrumenta obsidionalium artium <se> trans-
 tulerunt: (I β)
 et quia nec arietibus admovendis III δ
 nec ad intemptandas machinas vel ut possint
 forari cuniculi II γ
- 15 inveniebatur usquam habilis locus, I δ
 disparatione brevi civitatem Natisone amni prae-
 terlabente, III γ
 commentum excogitatum est IV γ θ
 cum veteribus admirandum. III δ
- (9) constructas veloci studio ligneas turres I δ
 20 propugnaculis hostium celsiores III δ
 inposuere trigeminis navibus II δ
 valde sibi conexas I γ
 quibus insistentes armati uno parique ardore I γ I γ
 prohibitores dispellere II γ
- 25 conlatis ex propinquo viribus nitebantur; III δ
 subterque expediti velites a turrium cavernis
 egressi I γ
 iniectis ponticulis 7 quos ante compagnarant III γ
 transgredi festinarunt, III δ
 indiviso negotio II γ
- 30 ut dum vicissim missilibus se petunt et saxis I γ δ
 utrimqueseclus alte locati, I γ
 hi qui transiere per pontes, I γ δ
 nullo interpellante, III γ
 aedificii parte convulsa I γ
- 35 aditus in penetralia <hostium> reserarent. (III δ)

12 se *ins. Bentl.* 35 penetrali *lac. serarent lac. iterum V* penetralia
 reserarent *iterum Gelen. sine lac. hostium et sed inserui*

(10)	⟨sed⟩ iterum summa coepti prudentis	Iγ
	aliorsum evasit;	Iγ
	cum enim adventarent iam turrets,	Iγδ
	contortis malleolis madentibus pice,	IIγ Iδ
5	harundine quin etiam ⟨et⟩ sarmentis,	(III δ ε)
	ac vario fomite flammaram incessebantur,	III γ
	quae quoniam incendio celeri	II δ
	ponderibusque trepide superstantium	IV δ
	inclinatae prociderunt in flumen,	Iγδ
10	armatorum aliqui per earum fastigia interibant,	III δ
	eminus confixi tormentis.	Iγ
(11)	inter quae destituti pedites post navalium so-	
	ciorum occasum	Iγ
	obtriti sunt saxis inmanibus,	IIγ
	praeter paucos quos morte scilicet per inpedita	
	suffugia	IIγ
15	velocitas exemerat pedum.	Iδ
	ad ultimum certamine protracto in vesperam,	IIγδ
	datoque signo in receptum ex more,	Iγδ
	ambo digressi	Iγ
	diei residuum animis egere disparibus.	IIγ IIγ
(12) 20	munitorum enim maerores,	Iγ
	funera lugentium propria,	IIδ
	prohibitores spe iam superandi firmabant,	Iγ
	licet ipsi quoque paucos gemebant amissos.	Iγ
	properabatur tamen nihilo minus	Iδ
25	et quantum recreandis viribus quiete et cibo	
	satis fuit tributo	Iγ
	per noctis integrae spatium,	IIδ
	reparatur lucis exordio proelium	IIδ
	incitamento tubarum.	Iγ
(13)	et quidam elatis super capita scutis, [ut pug-	
	naturi levius]	Iδ
30	alii vehentes umeris ut antea scalas,	Iδ
	ferventique impetu procurrentes,	IIIδ
	pectora multiformium telorum ictibus exponebant.	IIIδ
	alii ferratas portarum obices effringendas adorti	Iγ
	ultra ignibus petebantur	IIIδ
35	vel saxis muralibus oppetebant.	IIIδ

5 et inserui: cf. p. 127, l. 19; p. 137, l. 22 17 post receptum male interpretur Gardt. 29 ut pugnaturi levius seclusi, quibus verbis ineptus quidam interpretari conatus est illud elatis super capita scutis: v. p. 235

	quidam fossas audentius transire conati	I γ
	repentinis eorum adsultibus 7 qui erumpebant	
	clanculo per posticas	III δ ε
	ruebant incaute	I γ
	vel saucii discedebant.	III δ
5	recursus enim ad moenia tutior;	II δ
	vallumque antemuranum cespitibus fultum	I δ
	insidiantes ab omni discrimine defendebat.	III δ
(14)	et quamquam prohibitores 7 duritia bellorumque	
	artibus antistarent,	III δ
	quibus nihil praeter moenium supererat adiumentum,	III δ
10	collectus tamen ex potioribus numeris miles,	I δ
	diurnas ferre nequiens moras,	I δ
	suburbana omnia circumibat,	III δ
	diligenter inquirens	I γ
	qua vi vel machinis posset	I δ
15	patefactam inrumpere civitatem.	III δ
(15)	quod ubi patrare non poterat,	II γ δ
	magnitudine vetante difficultatum,	III γ
	obsideri remissius coepta est:	II δ ζ
	et excubiis stationibusque relictis,	I γ
20	praesidiarii milites	II δ
	vastantes agros propinquos	I γ
	omnibus congruentibus abundabant,	III δ
	raptorum pleráque	I γ
	concorporalibus suis inperientes.	III γ
25	unde largiore admodum potu	I δ
	saginisque distenti marcebant.	I γ
(16)	his relatione Immonis consortiumque cognitis,	
	Iulianus,	III δ
	Constantinopoli etiámtum hibernans,	I γ
	sollerti remedio turbatis consuluit rebus;	II γ I δ
30	moxque Agilonem magistrum peditum ea tem-	
	pestate probe cognitum miserat,	II δ
	ut viso honoratissimo viro	I δ
	compertaque per eum morte Constantii	II γ
	solveretur obsidium.	II γ
(17)	inter quae ne cessaret Aquileiæ oppugnatio,	IV δ
35	cum in reliquis opera consumeretur incassum,	I γ

I fossas audentius *Eyssenh.* f. addentius *V* fossam fidentius *Gardt.*
 23 pleráque *v. p.* 209 28 etiámtum *v. p.* 207 32 Constanti *V*

	placuit resistentes acriter ad deditionem siti con-	
	pelli:	I γ
	et ubi aquarum ductibus intersectis	III δ
	nihilo minus celsiore fiducia repugnarent,	III δ
	flumen laboribus avertitur magnis,	I δ
5	quod itidem frustra est factum.	I γ δ
	attenuatis enim avidius bibendi subsidiis	II γ
	hi quos temeritas clauserat	II δ
	contenti putealibus aquis 7 parce vixerunt.	I γ
(18)	quae dum agitantur casibus antedictis,	III δ
10	supervenit ut praeceptum est Agilo,	II γ δ
	scutorumque densitate contextus	I γ
	prope fidenter accessit;	I γ
	multaque locutus et vera	I γ δ
	quibus Constantii obitum	(II δ)
15	firmatumque Iuliani docebat imperium,	II γ
	non sine conviciis	II γ
	confutabatur ut fallax.	I γ δ
	nec ei quisquam credidit gesta narranti	I γ
	antequam pacta salute	I γ
20	susceptus ad pugnaculum solus	I δ
	fide religiosius reddita	II δ
	ea quae docuerat replicaret.	III δ
(19)	his auditis ex diuturno angore portis reclusis	I γ I γ
	omnes effusi	I γ
25	suscepere laeti pacificum ducem;	I δ
	seque purgantes,	I γ
	Nigrinum totius furoris auctorem	I γ
	paucosque alios obtulerunt,	III δ
	eorum supplicio	II γ
30	laesae crimina maiestatis et urbis aerumnas	III δ I γ
	expiari poscentes.	I γ
(20)	paucis denique post diebus 7 exploratius spectato	
	negotio,	II γ
	Mamertino tum iudicante praefecto praetorio,	II γ
	Nigrinus ut acerrimus belli instinator	I γ
35	exustus est vivus,	I γ δ
	Romulus vero post eum et Sabostius curiales	III δ
	convicti sine respectu periculi	II γ
	in studia saeviusse discordiarum	III γ

6 avidius scripsi: cf. II. 101. 13; 100. 20: avidioribus V 14 Constanti V

	poenali consumpti sunt ferro.	I γ δ
	residui omnes abierunt innoxii	II γ
	quos ad certaminum rabiem	II δ
	necessitas egerat non voluntas.	III δ ε
	5 id enim aequitate pensata statuerat	II γ
	placabilis imperator et clemens.	I γ δ
(21)	et haec quidem postea gesta sunt:	II δ ζ
	Iulianus vero agens etiam tūm apud Naëssum	II β δ
	curis altioribus stringebatur,	III δ
10	multa utrimquē pertimescens.	III δ
	formidabat enim ne clausorum militum apud	
	Aquileiam repentino adsultu	I γ
	obseratis angustiis Alpium Iuliarum,	III δ
	provincias et adminicula perderet	II δ
	quae exinde sperabat in dies.	I γ δ
(22)	15 itidemque opes orientis magnopere verebatur,	III δ
	audiens dispersum per Thracias militem	II δ
	contra vim subitam cito coactum	I γ
	adventare Succorum confinia	II γ
	comite Martiano ducente.	I γ
20	sed tamen congrua instantium sollicitudinum moli	I δ
	ipso quoquē agitans,	II δ
	efficaciter Illyricum contrahebat exercitum,	II γ
	pulvere coalitum Martio	II δ
	promptumque in certaminibus bellicoso iungi	
	rectori.	I γ
(23)	25 nec privatorum utilitates	III γ
	in tempore adflagranti despiciens,	II γ
	litesque audiens controversas	III δ
	maxime municipalium ordinum	II δ
	ad quorum favorem propensior	II γ
30	iniuste plures muneribus publicis adnectebat.	III δ
(24)	ibi Symmachum repertum et Maximum	II γ δ
	senatores conspicuos,	II γ
	a nobilitate legatos ad Constantium missos,	I δ
	exinde reversos honorifice vidit:	I δ
35	et potiore posthabito	II γ
	in locum Tertulli	I γ
	Maximum urbi praefecit aeternae,	I γ
	ad Rufini Vulcatii gratiam	(II δ)

	cuius sororis eum filium norat.	I δ
	hoc administrante alimentaria res abundavit	I β
	et querelae plebis excitari crebro solitae cessa- verunt.	III δ
(25)	tunc ut securitatem trepidis rebus adferret	I γ
5	et oboedientium nutriret fiduciam,	II γ
	Mamertinum praefectum praetorio per Illyricum	IV δ ε
	designavit consulem et Nevittam,	III δ ε
	qui nuper ut primum augendae barbaricae vili- tatis auctorem	I γ
	inmoderate notaverat Constantinum.	III δ
(XIII. 1)	10 his ac talibus eo inter spem metumque nova negotia commovente,	III δ
	Constantius apud Edessam,	IV δ ζ
	exploratorum relationibus variis anxius,	II δ
	in rationes diducebatur ancipites,	II γ
	nunc ad concursatorias pugnas militem struens,	I δ I δ
15	nunc si copia patuisset	III δ
	obsidione gemina Bézabden aggressurus ;	III δ
	consultans prudenter	I γ
	ne mox partes petiturus arctos	I γ
	inprotectum Mesopotamiae relinqueret latus.	I δ
(2)	20 verum consiliorum ambiguum	II γ
	retinebant multiplices morae,	I δ
	tardante trans Tigridem rege	I δ
	dum moveri permitterent sacra,	I δ
	nam si permeato flumine nullum qui resisteret invenisset,	III δ
25	absque difficultate penetrarat Euphratem :	I γ
	alioqui ad civilia bella custodiens militem,	II δ
	timebat eum periculis obiectare circummuranis,	III γ
	firmitatem moenium munimenti	III δ
	defensorumque alacritatem expertus.	I γ
(3)	30 ne quiesceret tamen 7 neve condemnaretur inertiae	II γ
	Arbitionem et Agilonem,	III γ δ
	⟨pedestris⟩ equestrisque militiae magistros,	I γ
	cum agminibus maximis properare coegit,	I γ
	non ut lacerarent Persas in proelia,	II γ δ
	35 sed praetenturis iuncturos citeriores Tigridis ripas,	I δ

	et speculaturos quonam rex erumperet violentus.	III δ
	addebatque monendo saepius et scribendo	III δ ε
	ut si multitudo transire coepisset hostilis	I γ
	referrent citius pedem.	I δ
(4)	5 dumque conlimitia iussa custodiunt duces	I δ I δ
	et occulta fallacissimae gentis observantur,	*
	agens ipse cum parte validiori exercitus	II γ
	curabat urgentia velut pugnaturus	*
	oppidaque tuebatur excursu.	I γ
	10 speculatores vero et transfugae súbinde venientes	III δ
	repugnantia prodebant,	I γ
	ideo futurorum incerti	I γ
	quod apud Persas nemo consiliorum est conscius	II γ δ
	praeter optimates taciturnos et fidos,	I γ δ
	15 apud quos silentii quoque colitur numen.	I δ
(5)	accersebatur autem a memoratis ducibus impe-	
	rator adsidue,	II γ
	orantibus ferri sibi suppetias :	II γ
	testabantur enim se non nisi coactis in unum	
	viribus cunctis	I δ
	posse impetum regis ardentissimi sustinere.	III δ
(6)	20 quae dum aguntur ita sollicite,	II γ
	nuntii percrebuere certissimi	II γ
	quorum clara fide conpertum est	II γ ζ
	Iulianum Italiam et Illyricum cursu celeri praeter-	
	gressum	III δ
	claustra interim occupasse Succorum,	I γ
	25 accita undique praestolantem auxilia	II γ
	ut multitudine stipatus armorum	(I γ)
	pervaderet Thracias.	II δ
(7)	quo cognito maerore offusus Constantius	II γ
	solacio uno sustentabatur	III γ
	30 quod intestinos semper superaverit motus ;	I δ
	re tamen magnam ei difficultatem	III γ
	ad capessendum consilium adferente,	III δ
	id elegit potissimum	II γ
	ut vehiculis publicis inpositum paulatim prae-	
	mitteret militem.	II δ

7. 9. v. p. 172 26 armorum I^r armatorum Gardt. male cf. II. 78. 5 ;
 256. 5 ubi codd. armorum, et I. 187. 12. Cf. Schneider, Quaest. Ann., Brol.
 1879, p. 48. n. 1.

- inminente casus atrocitati velocius occurrurum. III γ III δ
 (8) omniumque consensu adprobata sententia, II γ
 pergebant ut praeceptum est expediti. III γ δ
 eique haec disponenti III γ δ
 5 luce postera nuntiatur III δ
 regem cum omni manu quam duxerat II γ δ
 ad propria revertisse, III δ
 auspiciis dirimentibus; IV δ
 lenitoque metu I δ
 10 revocatis omnibus praeter eos quos consuetudo
 praesidio Mesopotamiae destinarat III δ
 reversus est Hierapolim. IV γ δ
 (9) summa itaque coeptorum quorsum evaderet
 ambigens, II δ
 cum in unum exercitus convenisset, III δ
 omnes centurias et manipulos et cohortes III δ ε
 15 in contionem vocavit concinentibus tubis; I γ I δ
 oppletoque multitudinis campo, I δ
 ut eam ad firmanda promptius adigeret imperanda, III δ
 tribunali celso insistens (I γ)
 stipatusque solito densius, II δ
 20 haec prosecutus est II β ζ
 ad serenitatis speciem et fiduciae vultu formato. I γ

(adhortatio Constantii)

- (10) Sollicitus semper nequid re levi vel verbo com-
 mittam I γ
 inculpatae parum congruens honestati, III δ
 utque cautus navigandi magister I γ
 25 clavos pro fluctuum motibus erigens vel inclinans, III δ ε
 conpellor nunc apud vos, amantissimi viri, I δ
 confiteri meos errores, I γ
 quin potius si dici liceat verum, I δ
 humanitatem quam credidi II γ δ
 30 negotiis communibus profuturam. III δ
 proinde ut sciri facilius possit I δ
 quae sit huius concilii convocandi materia, II γ
 accipite quaeso aequis auribus et secundis. III δ ε
 (11) Gallum patrualem meum tempore quo confun-
 dendis rebus pertinaciter Magnentius inhaerebat, III δ

18 insistens *Bentl.*: sistens *V*, cf. I. 143. 4, 236. 25; II. 10. 11. 19 sti-
 patusque *Bentl.*: stipatoque *V*: cf. I. 91. 19; 254. 22; 266. 27 *passim*.

	(quem obruere vestrae virtutes),	I γ
	potestate Caesaris sublimatum	III δ
	ad orientis praesidium misi.	I δ
	qui cum a iustitia per multa visu relatuque nefaria defecisset,	III δ
	5 arbitrio punitus est legum.	I γ δ
(12)	atque utinam hoc contenta fuisset Invidia,	II γ
	turbarum acerrima concitatrix ;	III δ
	et angebat nos una sed segura doloris praeteriti recordatio.	IV δ
	at nunc aliud accidit,	II δ
10	ausim dicere praeteritis maestius,	II δ
	quod per fortitudinem vobis ingentiam adiumenta caelestia coërcebunt.	II γ
		III δ
(13)	Iulianus quem, dum circumfremescentes Illyricum nationes exteras oppugnatis,	III δ
	tuendis praefecimus Galliis,	II δ
15	levium confidentia proeliorum	III δ
	quae cum Germanis gessit semermibus	II γ
	ut vecors elatus,	I γ
	adscitis in societatem superbam 7 auxiliariis paucis	I δ
	feritate speque postrema 7 ad perniciosam audaciam promptis,	I δ
20	in noxam publicam conspiravit,	III δ
	aequitate calcata,	I γ
	parente nutriceque orbis Romani,	I γ
	quam tumentes spiritus tamquam favillas esse facturam	I γ
	perinde ut scelestorum ultricem,	I γ
25	et ipse expertus	I γ
	et docente antiquitate	III γ
	facile credo.	I δ
(14)	quid igitur superest,	II δ
	nisi ut turbinibus excitis occurramus,	III δ
30	subcrescentis rabiem belli	I δ
	antequam pubescat validius	II γ
	celeritatis remediis oppressuri ?	III δ
	nec enim dubium, favore numinis summi praesente	I γ
	cuius perenni suffragio 7 damnantur ingrati,	I γ

8 *fortasse* angeret 24 *perinde Eyssenh. deinde V: textus incertus*
scelestorum Vales, sceleste laetorum V per dittographiam s. factorum Gardt.

	ferrum impie praeparatum	III δ
	ad eorum interitum esse vertendum	I γ
	qui non lacessiti sed aucti 7 beneficiis pluribus	II δ
	ad insontium pericula surrexerunt.	III δ
(15)	5 ut enim méa mens augurat,	II γ δ
	iustitiaque rectis consiliis adfutura promittit,	I γ
	spondeo quod si ventum fuerit comminus,	II δ
	ita pavore torpescent	I γ
	ut nec oculorum vestrorum vibratae lucis ardorem	I γ
	10 nec barritus sonum perferant primum.	I δ
	<i>(fnis adhortationis)</i>	
(16)	omnes post haec dicta in sententiam <traxerat>	
	suam;	(I δ)
	hastasque vibrantes irati,	I γ
	post multa quae benevole responderunt,	(III δ)
	petebant duci se protinus in rebellem.	III δ ε
	15 qua gratia in laetitia imperator versus ex metu,	I γ δ
	contione mox absoluta,	III γ δ
	Arbitionem ante alios faustum 7 ad intestina bella	
	sedanda	I γ
	ex ante actis iam sciens,	I γ δ
	iter suum praeire	I γ
	20 cum Lanceariis et Mattiariis et catervis expe-	
	ditorum praecepit,	I γ
	et cum Laetis itidem Gomoarium,	IV δ
	venturis in Succorum angustias opponendum,	III δ
	ea re aliis antelatum	III δ
	quod ut contemptus in Galliis	II γ δ
	25 erat Iuliano infestus.	I γ
(XIV.1)	in hoc rerum adversarum tumultu	I γ
	haerens eius fortuna iam et subsistens	III γ δ ε
	adventare casum vitae difficilem	II γ
	modo non loquentibus signis	I δ
	30 aperte monstrabat.	I γ
	namque et nocturnis imaginibus terrebatur,	III δ
	et nondum penitus mersus in somnum	I γ δ
	umbram viderat patris 7 obtulisse pulchrum in-	
	fantem	I γ
	eumque susceptum 7 et locatum in gremio suo	I δ

5 mensam *V unde noli facere mens iam* (v. p. 207) 11 traxerat *Gelen.*
 ibant *Haupt*: cf. I. 112. 14: II. 68. 4 s. 13 responderunt *scripsi*: responderant *V*

	excussam sibi proiecissee longius sphaeram	I δ
	quam ipse dextera manu gestabat.	I γ
	id autem permutationem temporum indicabat,	III δ
	licet interpretantes placentia responderent.	III δ
(2)	5 post haec confessus est iunctioribus proximis	II δ
	quod tamquam desolatus	III δ
	secretum aliquid videre desierit	II γ
	quod interdum adfuisse sibi squalidius aestimabat ;	III δ
	et putabatur genius [esse] quidam tutelae salutis	
	adpositus	II γ
	10 eum reliquisse mundo citius digressurum.	III δ
(3)	ferunt enim theologi	II γ
	in lucem editis hominibus cunctis	I δ
	(salva firmitate fatali)	I γ
	huiusmodi quaedam 7 velut actus rectura numina	
	sociari,	III δ
	15 admodum tamen paucissimis visa	I δ
	quos multiplices auxere virtutes.	I γ
(4)	idque et oracula et auctores docuere praeclari,	I γ
	inter quos est etiam Ménander comicus,	II δ
	apud quem hi senarii duo leguntur :	I γ
	(versus omisi)	
(5)	20 itidem ex sempiternis Homeri carminibus	II γ
	intellegi datur	I δ
	non deos caelestes cum viris fortibus conlocutos,	III δ
	nec adfuisse pugnantibus vel iuvisse,	III δ ε
	sed familiaris genios cum isdem versatos.	I γ
	25 quorum adminiculis freti praecipuis	II γ
	Pythagoras enituisse 7 dicitur et Socrátes	III δ ε
	Numaque Pompilius 7 et superior Scipio	II δ
	et, ut quidam existimant, Marius	II δ
	et Octavianus cui Augusti vocabulum delatum	
	est primo,	I δ
	30 Hermesque Termaximus et Tyaneús Apol-	
	lonius,	II γ II β
	atque Plotinus	I γ
	ausus quaedam super hac re disserere mystica	II δ
	alteque monstrare	I γ
	quibus primordiis 7 hi genii animis conexi	
	mortalium	II γ

	eas tamquam gremiis suis susceptas tuentur	I γ
	[quoad licitum est]	
	docentque maiora si senserint puras	I γ I δ
	et a conluvione peccandi	I γ
	inmaculata corporis societate discretas.	I γ
(XV. 1)	5 ingressus itaque Antiochiam festinando Con-	
	stantius	II γ
	ad motum certaminum civilium ut solebat	III δ ε
	avide surrecturus	III δ
	paratis omnibus exire properabat inmodice,	II γ
	renitentibus plurimis murmure tenus:	I δ
	10 nec enim dissuadere palam audebat quisquam	
	vel vetare.	III δ ε
(2)	autumno iam senescente profectus,	I γ
	cum ad suburbanum venisset	I γ
	disiunctum exinde tertio lapide,	II δ
	Hippocéphalum nomine,	II δ
	15 lucente iam die	I γ δ
	cadaver hominis interfecti	III δ
	dextra iacens capite avulso conspexit	I γ
	contra occiduum latus extensum;	I γ
	territusque omine,	II δ
	20 finem parantibus fatis,	I δ
	destinatius ipse tendebat;	I γ
	venitque Tarsum,	I δ
	ubi leviofe febfri contactus	I γ
	ratusque itinerario motu	I δ
	25 imminutae valetudinis excuti posse discrimen	I γ
	petit per vias difficiles Mobsucrenas,	III δ
	Ciliciae ultimam hinc pergentibus stationem	III δ
	sub Tauri montis radicibus positam;	II δ
	egredique secuto die conatus	I γ
	30 invalente morbi gravitate detentus est;	II γ ζ
	paulatimque urente calore nimio venas	I δ
	ut ne tangi quidem corpus eius posset	I δ
	in modum foculi fervens,	I δ
	cum usus deficeret medelarum	III δ
	35 ultimum spirans	I δ
	deflebat exitium,	II γ

I quoad licitum est *seclusi ut interpolata vel ex margine in textum intro-*
ducta: v. p. 235 32 eius v. p. 224

	mentisque sensu tum etiam integro	II δ
	successorem suae potestatis statuisset dicitur	
	Iulianum.	III δ
(3)	deinde anhelitu iam pulsante letali conticuit,	II γ
	diuque cum anima conluctatus iam discessura,	III γ δ
5	abiit e vita	I γ δ
	tertium nonarum Octobrium	II γ
	imperii (tricesimo octavo) vitaeque anno quadra-	
	gesimo (quarto)	(I δ)
	et mensibus paucis.	I δ
(4)	post quae supremis cum gemitu conclamatis,	III δ
10	excitisque lamentis et luctu,	I γ δ
	deliberabant locum obtinentes in aula regia	
	primum	I δ
	quid agerent quidve moliri deberent;	I γ
	paucisque occulte super eligendo imperatore	
	temptatis	I γ
	incitante ut ferebatur Eusebio	II γ
15	quem noxarum conscientia stimulabat,	III δ
	cum novandis rebus imminens obsisteret Iulianus,	III δ
	mittuntur ad eum Theolaifus et Aligildus tunc	
	comites,	II γ δ
	mortem indicantes propinqui,	I γ
	et oraturi ut mora omni depulsa	I γ
20	ad obtinendum obtemperare sibi paratum ten-	
	deret orientem.	III δ
(5)	fama tamen rumorque loquebatur incertus	I γ
	Constantium voluntatem ordinasse postremam,	I γ
	in qua Iulianum ut praediximus scripsit [et]	
	heredem,	(I γ)
	et his quos diligebat fidei commissa detulit et	
	legata.	III δ ε
(6) 25	uxorem autem praegnantem reliquit,	I γ
	unde edita postuma eiusque nomine appellata	II δ III δ
	cum adolevisset matrimonii iure copulata est	
	Gratiano.	III γ δ
(XVI. 1)	bonorum igitur vitiorumque eius differentia vere	
	servata	I γ

7 tricesimo octavo, et quarto add. Wagner. Mea quidem opinione nihil mutandum: sin autem mutandum, alio modo id fieri oportet 23 et deleui Accursium secutus

	praecipua prima conveniet expediri.	III δ
	imperatoriae auctoritatis cothurnum ubique custo-	
	diens,	II γ
	popularitatem elato animo contemnebat et magno ;	I γ δ
	erga tribuendas celsiores dignitates inpendio	
	parcus,	I δ
5	nihil circa administrationum augmenta	I γ
	praeter pauca novari perpessus,	I γ
	numquam erigens cornua militarium.	IV δ
(2)	nec sub eo dux quisquam cum clarissimatu pro-	
	vectus est :	II γ ζ
	erant enim ut nos quoque meminimus perfectissimi.	IV δ
10	nec occurrebat magistro equitum provinciae rector,	I δ
	nec contingi ab eo civile negotium permittebat.	III δ
	sed cunctae castrenses et ordinariae potestates	III δ
	ut honorum omnium apicem	II δ
	priscae reverentiae more	I δ
15	praefectos semper suspexere praetorio.	II γ
(3)	in conservando milite nimium cautus,	I δ
	examinator meritorum nonnumquam subscruposus,	III δ
	palatinas dignitates velut ex quodam tribuens	
	perpendiculo :	IV δ
	et sub eo nemo celsum aliquid acturus in regia	II γ δ
20	repentinus adhibitus est vel incognitus,	II β γ
	sed qui post decennium officiorum magisterium	
	vel largitiones vel simile quicquam	
	esset rector	I γ
	apertissime noscebatur.	III δ
	valdeque raro contigerat	II γ
	ut militarium aliquis	II δ
25	ad civilia regenda transiret,	I γ
	contraque non nisi pulvere bellico indurati	III δ
	praeficiebantur armatis.	I γ
(4)	doctrinarum diligens adfectator,	III δ
	sed cum a rhetorica per ingenium desereretur	
	obtunsum	I γ
30	ad versificandum transgressus	I γ
	nihil operae pretium fecit.	I δ
(5)	in vita parca et sobria	II γ δ

20 melius cadit si est secludis, ut fiat adhibitus vel incognitus (IV) : sed vide p. 207 22 magisterium vel largitiones quintam efficit formam

	edendi potandique moderatione valetudinem ita retinuit firmam	I δ
	ut raros colligeret morbos,	I δ
	sed eos non procul a vitae periculis:	II γ
	id enim evenire corporibus a lascivia dimotis et luxu	I γ δ
	5 diuturna experimenta 7 et probationes medendi monstrarunt.	I γ
(6)	somno contentus exiguo	II γ
	cum id posceret tempus et ratio,	II γ δ
	perque spatia vitae longissima	II γ
	inpendio castus	I δ
10	ut nec amaro ministro	I γ
	saltem suspicione tenuis posset redargui:	II γ
	quod crimen etiam si non invenit malignitas fingit	I δ
	in summarum licentia potestatum.	III δ
(7)	equitandi et iaculandi 7 maximeque perite diri- gendi sagittas	I γ
15	artiumque armaturae pedestris	I γ
	perquam scientissimus.	IV δ
	quod autem nec tersisse umquam nares in publico	II γ δ
	nec spuissse nec transtulisse in partem alterutram vultum	I δ
	aliquando est visus	I γ δ
20	nec pomorum quoad vixerat gustavisse	(III δ)
	ut dicta saepius praetermitto.	III δ
(8)	dinumeratis carptim bonis quae scire potuimus,	II γ
	nunc ad explananda eius vitia veniamus.	III δ
	cum esset in negotiis aliis	II δ
25	principibus mediis comparandus,	III δ
	si adfectatae dominationis amplam quandam falsam reperisset aut levem,	I γ δ
	hanc sine fine scrutando,	I γ
	fasque eodem loco ducens et nefas,	I γ δ
	Caligulae et Domitiani et Commodi	II γ δ
	inmanitatem facile superabat;	III δ
30	quorum aemulatus saevitiam	II γ
	inter imperandi exordia	II γ
	cunctos sanguine et genere se contingentes stir- pitis interemit.	III δ

10 *textus incertus* mare ministro *V*14 *perite malim* peritus20 vixerat gustavisse *scripsi* vixerat gustaverit *V*

(9)	addebatur miserorum aerumnis	I γ
	qui rei maiestatis imminutae vel laesae defere-	
	bantur	III γ
	acerbitas eius 7 et iracundae suspiciones	III γ
	in huiusmodi cuncta distentae.	I γ
5	et siquid tale increpisset	III γ
	in quaestiones acrius exurgens quam civiliter	IV γ ε
	spectatores adponebat his litibus truces;	I δ
	mortemque longius in puniendis quibusdam	I γ
	si natura permitteret	II γ
10	conabatur extendi,	I γ
	in eiusmodi controversiarum partibus etiam Gal-	
	lieno ferocior.	II γ
(10)	ille enim perduellionum crebris verisque adpetitus	
	insidiis,	II γ
	Aureoli et Postumi et Ingenui	IV δ ε
	et Valentis cognomento Thessalonici	III γ
15	aliorumque plurium 7 mortem factura crimina ali-	
	quotiens lenius vindicabat:	III δ
	hic etiam ficta vel dubia	II γ δ
	adigebat videri certissima	II γ
	vi nimia tormentorum.	III δ
(11)	iustumque in eiusmodi titulis	II δ
20	capitaliter oderat,	II δ
	cum maxime id ageret ut iustus aestimaretur	
	et clemens.	I γ δ
	et tamquam ex arida silva	I δ
	volantes scintillae	I γ
	flatu leni ventorum	I γ
25	adusque discrimina	II γ
	vicorum agrestium	II γ
	incohibili cursu perveniunt,	II γ
	ita ille quoque ex minimis causis	I δ
	malorum congeries excitabat,	III δ
30	Marci illius dissimilis principis verecundi,	III δ
	qui cum ad imperiale culmen in Syria Cassius	
	surrexisset,	III δ
	epistularum fascem ab eo ad conscios missum,	I δ
	perlatore capto sibi oblatum,	I γ

	ilico signatum exuri praecepit,	I γ
	agens adhuc in Illyrico,	II β γ
	ne insidiatoribus cognitis	II δ
	invitus quosdam habere posset offensos.	I γ
(12)	5 utque recte sentientes quidam arbitrabantur,	III γ
	virtutis erat potius indicium magnae	I δ
	imperio eundem Constantium sine cruore cessisse	I γ
	quam vindicasse tam inclementer.	III γ δ
(13)	ut Tullius quoque docet,	I δ
	10 crudelitatis increpans Caesarem	II δ
	in quadam ad Nepotem epistula,	II γ
	'neque enim quicquam aliud est felicitas' inquit	I δ
	'nisi honestarum rerum prosperitas.	[II γ]
	vel ut alio modo definiam,	[II γ]
	15 felicitas est fortuna adiutrix consiliorum bonorum,	[I γ]
	quibus qui non utitur	[*]
	felix esse nullo pacto potest.	[*]
	Ergo in perditis impiisque consiliis	[II γ]
	quibus Caesar usus est	[*]
	20 nulla potuit esse felicitas	[II γ]
	feliciorque meo iudicio Camillus exulans	[*]
	quam temporibus isdem Manlius,	[*]
	etiam si—id quod cupierat—regnare potuisset.'	[*]
(14)	id Ephesius quoque Heraclitus adserens monet	I δ
	25 et ab inertibus et ignavis	III δ ε
	eventus variante fortuna	I γ
	superatos aliquotiens viros fuisse praestantes:	I γ
	illud vero eminere inter praecipuas laudes,	I δ
	cum potestas in gradu	I γ δ
	30 velut sub iugum missa nocendi saeviendi(que)	
	cupiditate et irascendi	III γ δ
	in arce victoris animi tropaeum erexerit gloriosum.	III δ
(15)	ut autem in externis bellis hic princeps fuit	
	saucius et adflictus,	III δ ε
	ita prospere succedentibus pugnis civilibus	
	tumidus,	II δ
	et intestinis ulceribus rei publicae	IV δ ζ
	35 sanie perfusus horrenda:	I γ
	quo pravo proposito magisquam recto vel usitato,	III γ δ
	triumphalis arcus ex clade provinciarum	III γ

	sumptibus magnis erexit 7 in Galliis et Pannoniis,	IV δ ε
	titulis gestorum adfixis,	I γ
	quoad stare poterunt monumenta lecturis.	I γ
(16)	uxoribus et spadonum gracilentis vocibus et pa-	
	latinis quibusdam	I γ
	5 nimium quantum addictus	I γ
	ad singula eius verba plaudentibus	II γ
	et quid ille aiat aut neget	I γ δ
	ut adsentire possint obseruantibus.	IV γ
(17)	augebat etiam amaritudinem temporum	II δ
	10 flagitatorum rapacitas inexpleta,	III δ
	plus odiorum ei quam pecuniae conferentium;	IV δ
	hocque multis intolerantius videbatur	III δ
	quod nec causam aliquando audivit	I γ
	nec provinciarum indemnitati prospexit	I γ
	15 cum multiplicatis tributis et vectigalibus vexa-	
	rentur.	III δ
	eratque super his adimere facilis quae donabat.	III δ ε
(18)	Christianam religionem absolutam et simplicem	II γ δ
	anili superstitione confundens,	I γ
	in qua scrutanda perplexius quam componenda	
	gravius (versabatur),	(III δ)
	20 excitavit discidia plurima,	II δ
	quae progressa fusius aluit concertatione ver-	
	borum,	I γ
	ut catervis antistitum iumentis publicis ultro ci-	
	troque discurrentibus	IV δ
	per synodos quas appellant,	III δ ε
	dum ritum omnem ad suum trahere conantur	
	arbitrium,	II γ
	25 rei vehiculariae succideret nervos.	I δ
(19)	figura tali situque membrorum:	I γ
	subniger, luce oculorum edita, cernensque acutum,	I γ
	molli capillo,	I γ
	rais adsidue genis	I δ
	30 lucentibus ad decorem,	III δ ε
	usque ad pubem ab ipsis colli confiniis longior	II δ
	brevissimis cruribus et incurvis.	III δ ε
	[unde saltu valebat et cursu.]	
(20)	pollinctum igitur corpus defuncti	I γ

8 possint obseruantibus *v. pp. 182, 233*

19 versabatur *inserui*

	conditumque in loculis	II γ δ
	Iovianus etiāmtam protector domesticus	II γ
	cum regia prosequi pompa 7 Constantinopolim	
	usque iussus est	II δ ζ
	prope necessitudines eius humandum.	I γ
(21)	eique vehiculo insidenti 7 quod portabat reliquias,	II γ
5	ut principibus solet,	I δ
	annonae militaris offerebantur indicia	II γ
	(ut ipsi nominant proba)	I δ
	et animalia publica monstrabantur	III δ
	et ex usu crebrescebant occursus.	I γ
10	quae et alia horum similia	II γ
	eidem Ioviano imperium quidem	I δ
	sed vicarium et umbratile	(IV δ ε)
	ut ministro rerum funebrium portendebant.	III δ

12 sed vicarium *scripsi*, sede et assum *V*, sed et cassum *Accurs.*, unde sed cassum *Gelen. v. p. 173*

CHAPTER I. NATURE OF THE CLAUSULAE.

The most casual glances at the pages of the foregoing selection from the Histories cannot but reveal the fact that Ammianus secured a rhythmical effect in his prose through the constant repetition of a limited number of accentual clausulae. It is almost equally obvious that the nature of each clausula is chiefly determined by two factors which must enter into it—the accentual cadence pure and simple, and the cæsura. Founding our classification of the clausulae, therefore, upon these two essential features, we shall discuss first the divers accentual cadences or *forms* that Ammianus uses, and next the various word-groups or *types* by which each form is rendered. Were Ammianus' clausulae purely accentual, we should not need to carry our investigation any farther; but although accent is always the principal factor in his rhythm, syllable-quantity is not left entirely out of account in it. We must therefore give this element a place in our discussion of the nature of his clausulae, which we shall conclude with a brief inquiry into the matter of their origin.

FORMS.

The following table displays the various forms that occur among the clausulae in Book XXI (I) and in the collection of sentence-endings previously described (II), and records the frequency with which they recur. In compiling these statistics I have departed from Gardthausen's text only in two sentence-endings.¹ In the latter collection all direct quotations are left out of account; in Book XXI only two citations from Cicero.

TABLE OF FORMS.

		Coll. I	Coll. II	Total
Regular	I $\tilde{\sim} \sim \sim \tilde{\sim} \sim$	648	873	1521
	II $\tilde{\sim} \sim \sim \tilde{\sim} \sim \sim$	385	202	587
Cadences	III $\tilde{\sim} \sim \sim \sim \sim \tilde{\sim} \sim$	345	681	1026
	IV $\tilde{\sim} \sim \sim \sim \sim \tilde{\sim} \sim \sim$	47	31	78
		1425	1787	3212

¹ Vol. I, p. 48, l. 14 I read *triclini* with the Ms. for *triclirii*; I. 88. I punctuate after *princeps* and construe *ob devotionem* with what follows. Strictly speaking I should not have introduced the first of these corrections into my tables, but, once admitted, it was easier to leave it than to remove it.

Brought forward .		1425	1787	3212
		Coll. I	Coll. II	Total
Irregular Cadences	A ~ ~ ~ ~ ~	19	13	32
	B ~ ~ ~ ~ ~	5	3	8
	C ~ ~ ~ ~ ~	7	5	12
	D ~ ~ ~ ~ ~	4	2	6
	Uncertain	1	1	2
		36	24	60
		1461	1811	3272

These results manifest unequivocally the uniformity of Ammianus' rhythm. His style is chiefly characterized by the inordinate repetition of the cadences I, II and III, which are presented in about 95 per cent of the clausulae. This proportion remains approximately the same whether we take all the clausulae into consideration or only those which end a sentence, although the discrepancy in the relative frequency of II and III in the two collections reveals the fact that II is used more often within the sentence than at its end, while the reverse is true of III. There can be no doubt, then, that these three are par excellence the favored forms.

Since cadence IV is counted in tens whereas the cadences just mentioned are counted in hundreds, I must set forth the reason that has governed me in classing it with these. It is primarily that IV would naturally be a rare clausula, because when it is constructed in two words it requires that the sentence or kolon end in a word of 5 or 6 syllables with antepenultimate accent (*militibus obscurissimis, constanti sollicitudine*), and such words are not common.¹ Furthermore, its occurrences are guaranteed by sound texts and its rhythm emphasized by responsion, since most of the cases in Book XXI stand in close proximity to one another.² It is therefore a good clausula, though, in comparison with the others, not a frequent one.

In connection with these four clausulae two other forms come up for discussion which are so rare that I have not found a single certain instance of either one in either of my two collections. In spite of this their status is quite different from that of the cadences which I have listed as irregular. These forms are:

V ~ ~ ~ ~ ~ ~ ~ ~ ~ ~
VI ~ ~ ~ ~ ~ ~ ~ ~ ~ ~

¹ The actual cases are for the most part present participles in the dative or ablative plural, and superlatives.

² See p. 204.

Of V I can cite five examples in Ammianus: II. 24. 25 *pondere circumveniretur*; 212. 27 *venerint allegationum*; 242. 18 *veritus ut adhuc durantem*; 268. 20 *eminuit at Sebastiani*; 269. 19 *erat cum moderatione*. To these should perhaps be added three ambiguous clausulae in Book XXI.¹ Of VI I have only two instances: II. 79. 19 *postea Constantinopoleos*; 214. 6 *Aesopi cavillationibus*. It is possible that some instances of one form or the other may have escaped me, but they cannot be numerous. Consequently both the forms are extremely rare. But we must not let this move us to doubt their legitimacy, for all of the texts in which they occur seem to be sound and are very difficult to assail. Moreover, their rarity finds adequate explanation in the motive that prompted their use: they were brought into employment simply as a means of handling long words which could not easily be disposed of otherwise.² It is noteworthy that, if we except the three ambiguous cases of V in Book XXI, all the examples come from the last 9 books—in fact, 5 of them from the last two books. This appears to indicate a late recognition of these forms, and a slightly increasing tendency to use them, once they are recognized. The fact that their occurrences are not in responsion but isolated is somewhat surprising. I can account for it only on the hypothesis that Ammianus regarded them as extensions of III and IV, and did not feel that they broke the rhythm. It is obvious that forms V and VI stand in the same relation to III and IV in which the latter stand to I and II. Using metrical terms to define accentual rhythm (as we do in dealing with English poetry) we may say that each of these clausulae has

¹ P. 142, l. 14 *trahendūmq̄ si reniteretur*, listed as doubtful (see below); p. 154, 6–8 *fallacissimae gentis observantur* and *urgētia velut pugnatūrus*—two clausulae in apparent responsion, listed as examples of A (see below).

² I note three cases in which a final word of 6 syllables with penultimate accent is not preceded by an antepenultimate word, but they are all corrupt. In I. 83. 5 *correxerit et liberalitate* the Ms. reads *correxit et libertate* (III), which should be retained in spite of the change in tense *egerit-correxit*. (v. Löfstedt, *Beiträge zur Kenntnis d. später. Lat.* p. 70 ff.) In II. 12. 14 *amittit intempustos* the ms. has *intempstiosos*, corrected into *intempustos* by a later hand: the reading of Accursius *intempstivos* is in better accord with the usage of Ammianus. In II. 64. 20 *somniorum adsiduitate* we have a case of hidden corruption: a verb has fallen out (v. Günther, *Phil.* 50, p. 69) and it is most natural to supply it at the end of the clause, after *adsiduitate*. As for words like *cavillationibus*, I have not found any instance of their employment before a pause except in the two cases cited above.

a dactylic-trochaic cadence.—they differ from one another only in the number of trochees that follow the dactyl.¹ The longer forms, in consequence of this similarity, might well be used out of responson, and the lack of it is certainly not a sufficient reason for expelling them from our text.

Coming now to the four cadences A, B, C and D, listed as irregular, we may sum up their status in saying that they were certainly avoided by Ammianus and probably avoided altogether.

None of these cadences is of such a sort as to be naturally uncommon. In a text in which no attention is paid to rhythm (there are few, if any, such among the ancient authors, but a modern writer of Latin will do for a test) all of them must needs occur very frequently. But in Ammianus, taken all together, they are less frequent in our text than the cadence IV, which would naturally be very rare. This fact can only be interpreted as evincing a strong disinclination on the part of Ammianus to employ these cadences. It justifies us in the statement that his rhythm is as much characterized in a negative way by their avoidance as it is in a positive way by the abnormal frequency of the cadences I, II and III.

Under these circumstances it is natural to draw the inference that the cadences in question were avoided altogether, and that their appearance in our text is to be attributed to corruption. And in fact a study of the individual passages in which they occur makes it evident that not one of the four cadences can be called valid with any degree of certainty: on the contrary it is extremely probable that they are each and all corrupt. To put the reader in possession of sufficient evidence on this point I submit a full list of the instances found in Book XXI and in my collection of sentence-endings.²

¹ Thus I *póndere vénit* = dactyl + trochee, III *póndere círcumvénit* = dactyl + 2 trochees, V *póndere círcumvénirétur* = dactyl + 3 trochees; II *póndere véniet* = dactyl + 1½ trochees (or dactyl-dactyl), IV *póndere círcumvéniet* = dactyl + 2½ trochees (or dactyl-trochee-dactyl), VI *póndere círcumvéníentibus* = dactyl + 3½ trochees (or dactyl-trochee-trochee-dactyl).

² Cases from the former source are cited in the order in which they occur, with references to page and line of this treatise; those from the latter are grouped according to the cadence represented, and the references are to page and line of Gardthausen's edition. V = Vat. Lat. 1873, of which all other existing codices are copies.

Book XXI.

- (1) p. 125. l. 18 multa et urgentia *Omit* et. Cf. curabat urgentia 254. 8; residua urgentia 294. 8.
- (2) 127. 21 coniectura fallerentur. interdumque *Read* fallerentur interdum. quae *with Bentley and Madvig*.
- (3) 128. 7 prospecta revertamur *Perhaps* proposita rev. Cf. I. 14. 28: II. 237. 22: II. 126. 11 proposita veniamus.
- (4) 129. 14 Vadomarii exorsos *Read* Vadomarii: *for evidence that Ammianus uses both forms of the genitive see p. 233*.
- (5) 131. 19 diversorium rediit *Read* redit (*Ammianus always accents rediit, interiit, etc. on the penult: v. p. 211*).
- (6) 131. 20 agi conveniret *V* conveniet, *which should be retained, in accordance with the usage of Ammianus: cf. I. 20. 7, and Petschenig Phil. 50 p. 348*.
- (7) 133. 8 potuerunt et probari *The sense demands* poterunt, *as Haupt has pointed out (Ind. Lect. Berol. 1874)*.
- (8) 133. 9 abiectius absolvam *V* abiectis: *it is better to assume a lacuna with Wagner and Eysenhardt than to read abiectius with Valesius and Gardthausen*.
- (9) 134. 17 sedulam et solitam *V* sollitam: *read* sollicitam *with Müller and Kiessling; so also Löfstedt, Eranos, 1909*.
- (10) 134. 28 virtutum pervulgatae *Transposing* pervulgatae virtutum *gives a better order, since Ammianus is very fond of traiectio*.
136. 8 ff. Amphilocheius quidam extribuno A
 (11-14) Paphlago quem dudum sub Constante militantem A
 discordiarum sevisse causas C
 inter primores fratres C
 suspiciones contiguae veritati pulsabant I

The arrangement which I give is merely an attempt to extract some sort of rhythm from this passage without resorting to conjecture. That it represents the effect which Ammianus intended to produce I do not believe, since the first pause would naturally follow Paphlago rather than tribuno, and there is no pause after causas. If we may assume that he accented Paphlago on the penult (v. p. 216) this would give us a regular cadence (I γ) at the end of the first kolon: the following (quem —pulsabant) may have constituted a single long kolon, or may possibly conceal corruption.

- (15) 136. 37 *reperitus solus* *Insert est, with Accursius: cf. I. 70.14.*
- (16) 138. 2 *Romanis inlaturi* *Transpose.*
- (17) 139. 6 *metueret offensam* *Read metuet ut: see Hassenstein, p. 37ff. and Schickinger, p. 7ff. The following verb properabat in the same clause has already been altered to properabit by Kiessling, and there is no reason for retaining metueret. Cf. I. 289.31 laederet ut offensus.*
- (18) 143. 2 *segne ratus* *V Segem catus: read segnius ratus with Novák (Curae Ammian., Prague 1896).*
- (19) 143. 24 *conveniet ostendi* *V conveniet et ostendi: Eysenhardt reads convenienter ostendam. To me it seems that an infinitive (perhaps describi) has fallen out of the text before conveniet.*
- (20) 145. 17 *horum similem* *With Gelenius I have inserted cuiusquam: This emendation is not, however, necessary to secure a regular clausula, for gloria horum similem gives cadence IV.*
- (21) 149. 5 *quin etiam sarmentis* *In conformity to the usage of Ammianus I would insert et before sarmentis (cf. 232. 8; 240. 23), but emendation is not necessary as far as concerns the rhythm, for etiam sarmentis gives I γ.*
- (22) 149. 29 *ut pugnaturi levius* *These words are to be bracketed as a marginal gloss which has crept into the text, and which embodies an erroneous explanation of elatis—scutis. The author of the gloss never saw a testudo in operation. (On glosses in the text, see p. 235ff.)*
- (23) 151. 14 *Constanti obitum* *It is not at all certain that we should look for a clausula here, but one is easily obtained by reading Constantii.*
- (24) 152. 38 *Vulcati gratiam* *Read Vulcatii.*
- (25–26) 154. 5 ff. *dumque conlimitia iussa custodiunt duces et occulta fallacissimae gentis observantur * agens ipse cum parte validiori exercitus curabat urgentia velut pugnaturus * oppidaque tuebatur excursu*

At first glance this seems a case of respension in A: it is not certain, however, for (1) the respension may be in V: fallacissimae gentis observantur, urgentia velut pugnaturus, or (2) it may be that the clausulae are III γ, gentis observantur (p. 233) and velut propugnaturus (Gelenius). The latter view seems to me preferable.

- (27) 154. 26 stipatus armatorum *V* armorum, which should be retained: cf. p. 154, note.
- (28) 155. 18 celso sistens *Read* insistens: cf. p. 155, note.
- (29) 157. 11 ibant suam *The verb is omitted in V: ibant Haupt* (a suggestion on which he himself laid no weight). *Read* traxerat with *Gelenius*, comparing I. 112. 14 and II. 68. 4 ff.
- (30) 157. 13 benivole responderant *Read* responderunt.
- (31) 159. 1 quoad licitum est *A gloss on the foregoing words.*
- (32) 160. 23 scripsit et heredem *The word et (which is entirely out of place in the text) is not to be found in the earlier editions.*
- (33) 162. 20 vixerat gustaverit *Read* vixerat gustavisse: the corruption is due to the influence of the preceding word vixerat aided by a certain similitude in the endings -erit and -isse.
- (34) 165. 19 componenda gravius *In my opinion a word (perhaps versabatur) has been lost after gravius: as the text stands, the relative clause which ends in these words has no verb, for excitavit is the verb of the main clause.*
- (35) 166. 12 sed cassum et umbratile *V* sede et assum, hence sed et cassum *Accursius* (*Eyssenhardt*), sed cassum *Gelenius* (*Gardthausen*). *I am convinced that the proper reading is sed vicarium. This is just as near the reading of V as Accursius' sed et cassum, but in the latter conjecture et is indefensible and cassum is nearly synonymous with umbratile. On the other hand vicarium not only is recommended by the rhythm but adds point to the sentence. Jovian, riding on the bier of Constantius, received homage in lieu of the dead emperor: it portended for him imperium quidem sed vicarium et umbratile ut ministro rerum funebrium. And there is especial point in the adjective in view of the confusion caused among the soldiers when he was proclaimed emperor by the similarity of the names Iovianus and Iulianus (see XXV. 5. 6).*

Sentence-endings

(arranged according to cadence)

A

- (1) I. 26. 28 *agitari conperissent* *V* *nove res agitari conpissent*; *in this one needs only to correct conpissent to coepissent with Gelenius. On coepi and coeptus sum see Novák, p. 80.*
- (2) 102. 5 *stetere cuneati* *V* *cunctanti, Reinesius cuneati, Read cunctantes.*
- (3) 103. 16 *verbis hortabatur.* *The intolerable baldness of this expression makes it evident that something has fallen out of the text. The whole passage needs an overhauling, for as Langen long ago pointed out (Emend. Ammian., Düren, 1867), the words cautior sui in the following sentence constitute an undeserved slur on Julian's courage of which Ammianus would have been incapable. As an attempt at reconstruction I offer: verbis hortabatur et <factis>, quoniam . . . Augustus existimabat cautior sui. hostium(que) tela etc.*
- (4) 118. 32 *signis ostendentes* *V* *signibus (followed in Cod. Petrinus), v² and Gelenius signis. For his signis read insignibus.*
- (5) II. 250. 1 *cruditate festinabat* *V* (*cf. Eysenhardt*) *festinabat: read firmabat.*
- (6) 273. 20 *quibus petebantur* *Pronounce quibus: see p. 228.*
- (7) I. 70. 26 *difficile pervadunt* *V* *pervaduntur, Haupt pervadunt. The passage should be so reconstructed as to retain pervaduntur.*
- (8) 82. 13 *munera curabant* *Valesius inserted munera: substitute, perhaps, munus.*
- (9) 175. 21 *februm arescunt* *V* *arescentes, Gelenius arescunt; arescentes is perhaps defensible on the assumption that contra is a preposition.*
- (10) 194. 18 *eximit abruptis* *Read exemit (Gelenius).*
- (11) 84. 11 *exarserat in maius* *in is conjecturally supplied: better exarsit in maius.*
- (12) 191. 32 *globos se inmisit* *se Gelenius: read sese or transpose.*
- (13) II. 206. 29 *secius hoc modo* *V* *rectus: read secus with Accursius, comparing I. 320. 23. (On the inconsistent accentuation hoc modo, huiusmodi see p. 210*

B

- (14) I. 18. 11 lapsorum ac lasciviam *V* ad: *read* atque: *cf.* I. 16. 26.
 (15) 142. 5 dedendi se consilium. *Read* sese or *transpose*.
 (16) 159. 3 a fuit quin caperer *V* fuit: *perhaps this reading should be retained. But quin may be pronounced as a dissyllable: v. pp. 227, 229.*

C

- (17) I. 145. 7 destinatas remearunt sedes *Müller inserted ad before destinatas: I should put it before sedes.*
 (18) 145. 23 ad res consurrexit novas *V* consurrexerit (*Clark*).
 (19) II. 161. 4 misit plebem *Transposition must be resorted to (plebem misit conductam) unless one reads conducticiam m. p.*
 (20) 196. 8 trucidari securum fecit *Haupt conjectured secure fecit, Eyssenhardt reads securum efficit. In my opinion Ammianus wrote secure praecepit: cf. II. 173. 21; I. 62. 31; 94. 33; 137. 27.*
 (21) 237. 19 portendatur norunt *V* portetur, *Eyssenhardt* portendatur. *I should prefer* poscitur: *cf. poscebatur* II. 168. 12.

D

- (22) II. 226. 3 esse [invidiam] sociam *Gardthausen brackets invidiam: read individuum with Valesius.*
 (23) 271. 25 arduo in munimento conditos *Set arduo after conditos: V reads ardor, which shows that the eye of the scribe was caught by ardor, below. Hence the transposition might easily occur.*

The only irregular cadence which, on a *priori* ground, might be expected to occur in Ammianus is that type of A in which the word-division follows the first unaccented syllable (*ille properabat*). As Meyer has pointed out, there are some writers who use this clausula, though few of them employ it in any great frequency.¹ He accredits Ammianus with sporadic use of it, on the basis of about 15 cases in 800 sentence-endings. But in this matter there is a discrepancy between Meyer's results and mine.² Among the 1461 clausulae in Book XXI I find 10 cases, among 1811 sentence-

¹ See p. 121, and *Ges. Abh. p. 260, p. 263 Anm. 1.*

² The difference is probably due to the fact that long and careful study of the Histories has enabled me to ascertain a number of peculiarities in the pronunciation of Ammianus which he was naturally unable to notice in the hasty examination of a limited material.

endings 6: in all, 16 cases, in 3272 clausulae, not one-fourth the proportion that Meyer's figures assign to Ammianus. Furthermore, a careful scrutiny of the preceding list will disclose that, in point of fact, there is very little evidence for the occurrence of this clausula in our author at all.

Of the 10 instances in Book XXI, 4 are isolated; in 2 of the 4 (nos. 6 and 27) the reading of the manuscript, which gives a regular clausula, is every way preferable, and of the other two (10, 16) we may say at least that transposition gives a better word-order in view of Ammianus' excessive fondness for *traiectio*. The other 6 instances form 3 cases of apparent responsion. But 2 of these cases must be ruled out of court, for in one of them (11-12) it is unlikely that the irregular cadences precede pauses, and in the other (25-26) the interpretation of the cadences as A is uncertain. In the remaining case (2-3), we have two sentences ending in Meyer's clausula, separated by about half a page of text: in this interval there is a quotation from Cicero, in which the same clausula terminates a sentence. At first sight this seems a striking example of responsion, motivated by the Ciceronian cadence. It is indeed the strongest example that I have been able to find in Ammianus, but it is not as satisfactory as it appears. For in the first place, however natural such a procedure may appear to us, nowhere else in Ammianus is an irregular cadence in a quotation balanced by irregular cadences in the text.¹ This case is therefore exceptional, and the very fact that seems to argue in favor of it is in reality an argument against it. Secondly, the first occurrence of the clausula is easily disposed of by revising the punctuation. Thirdly, the sentence that follows the quotation is a *revocatio*, marking a return to the subject. But elsewhere in Ammianus these *revocationes* always terminate in a regular cadence.² Moreover, in the phrase *ad explicanda prospecta revertamur* we have a figurative use of *prospecta* which is unparalleled: the word usually employed in this sense is *proposita*. On all these grounds I consider that we should read *proposita* here.

¹ Cf. XV. 5. 23; XVI. 1. 5; XIX. 12. 18; XXII. 7. 4; XXIX. 5. 24. In the first citation, however, the reader should be warned that *ipsius promulgatam* does not correspond with *fortuna revocatur*, but (in virtue of Ammianus' pronunciation *ipsius*, on which see p. 211) with the preceding *sententiam Tullianam*, with which it also rhymes.

² Cf. *proposita veniamus* II. 126. 11; *propositum revertamur* I. 14. 28; *propositi revertamur* II. 237. 22; *propositi revertetur* I. 228. 29 (where Gardthausen admits the mistaken conjecture *reverteretur*); *restantia veniamus* I. 72. 3;

Turning now to the instances of Meyer's clausula among the sentence endings, we find still less evidence than in Book XXI. Four out of the six cases (1, 2, 4, 5) are not founded on the manuscript, which gives in each instance a regular clausula. Another (3) is certainly to be held corrupt on internal evidence, and the sixth may be explained on the basis of the peculiar but not otherwise unsubstantiated pronunciation *quibus*.¹ None of these cases is supported by responding clausulae in the surrounding text.

If the testimony for this clausula is weak, it is weaker still for the other types of A, and for the cadences B, C and D, for the admission of which there is no *a priori* argument. Yet it differs only in degree and not in kind, since there are examples of each of these clausulae that are superficially sound. More than that, we have among the sentence-endings (17, 18) an example of responsion in C quite as specious as the case in Book XXI just discussed, and I can cite one in D (II. 215. 15 *proferre gestiens = aequitatis tranitem*) which can only be disposed of by transposition in both clausulae.

For this reason it would not be logical to admit Meyer's clausula and exclude the others. Nor would it be logical to hold that cases of responsion in any cadence are valid, and to shut out the isolated cases, for in the first place the responsions are entirely too few in proportion to the isolated cases, and in the second place they are no more difficult to dispose of than the latter. Therefore we must assume either that Ammianus made an illogical and extremely infrequent use of all these irregular cadences, or that he did not employ any of them at all.

Between these alternatives the decision must be made, it seems to me, in favor of the latter, when the general condition of the text of Ammianus is taken into consideration. Were his text-tradition perfect, we should of course have a perfect reproduction of his clausulae; but, as we have already seen, it is so far from

instituta iam revertamur I. 201. 13; *ordines r.* II. 100. 24; *ordinem r.* II. 315. 25; *fleximus r.* II. 137. 27; *declinavimus r.* II. 214. 18; *tandem ad coepta* I. 75. 23; *referamus ad coepta* II. 103. 21; *ad ordinem remeabo coeptorum* I. 306. 32; (cf. II. 134. 18) *redeundum ad textum* I. 23. 6; *pergamus ad reliqua* I. 284. 7; II. 66. 5; *ad residua narranda pergamus* II. 63. 15; *redeamus ad cetera* II. 151. 22; *hinc ad exorsa* I. 128. 3; *repetetur ordo gestorum* I. 30. 29; *redeam unde divertit* I. 87. 14; II. 246. 10; *regrediar institutum* II. 209. 28. The list is, I think, complete; *transitiones*, marking the introduction of a new subject, are of course omitted.

¹ See p. 228, 230.

perfect as to be nearly the worst possible.¹ Consequently, in case Ammianus consistently restricted himself to the use of the regular forms, we could not expect to find a consistent reproduction of these forms in our text of his work. We should look for the introduction of a moderate number of irregular cadences of all descriptions; naturally some few of these cadences would be in close enough proximity to suggest respension, and in some few of them the corruption would be latent. And this is precisely the state of affairs that we find in our text. The probabilities, then, are strong against the validity of any of the irregular cadences.

We may therefore bring to a close our long discussion of the forms employed by Ammianus with the statement that except for two forms V and VI, used for the handling of long words and so infrequent as to play but an infinitesimal part in his rhythm, he seems to have used only the four forms I-IV, which, even in our corrupt text, are well-nigh universal.

TYPES.

To name the types in which the four regular forms occur I have adopted the system devised by Zielinski for the quantitative clausula. This consists simply in taking the longest form (IV) and assigning a Greek letter to each place in it where a cæsura may occur. Thus:

$$\begin{array}{cccccccc} \sim & \sim & \sim & \sim & \sim & \sim & \sim & \sim \\ \beta & \gamma & \delta & \varepsilon & \zeta & \eta & \theta & \end{array}$$

Consequently a clausula having but a single cæsura will be denoted by a single Greek letter, which will be β if the cæsura follow the first syllable, γ if it follow the second syllable, and so on: a clausula having two or more cæsurae will be denoted by two or more Greek letters, each determined after the method just described. A clausula having no cæsura is signified by the letter α .

Under this nomenclature the types which occur in Book XXI (Coll. I) and among my sentence-endings (Coll. II) are classified in the following list, which, for the second collection, also gives complete statistics as to the length of the first word in each type.

¹ See p. 122.

TABLE OF TYPES.

Form I.

	Coll. I	Coll. II			
			nosse confingit	171	
			perculus abscessit	140	
γ	353	509	periere conplures	143	509
			posteritatis ostendit	45	
			obstinationis extremæ	10	
			passibus citis	90	
δ	210	223	confluxerit Romam	104	223
			inferentibus plura	24	
			seditionibus possint	5	
			vilis et parva	22	
$\gamma\delta$	75	112	defensor et cautus	38	112
			aestimatur et salus	46	
			instituere non pauca	6	
β	7	24	sol aestimatur	23	24
			Thebais adpellatur	1	
$\beta\gamma$	1	2	hinc ad exorsa		2
$\beta\gamma\delta$	1	0	(id prae me fērens)		0
$[\alpha$	1	3	toleratūri		3]
	<u>648</u>	<u>873</u>			

Form II.

	Coll. I	Coll. II			
			semper innocui	21	
			vertuntur indaginem	25	
γ	195	99	properabat intrepidus	41	99
			velocitate letabilis	11	
			adulatione flagrantium	1	
			opifex callidus	18	
δ	104	28	suppeteret copia	7	28
			civitatibus perviis	3	
			asper et vehemens	7	
$\gamma\delta$	68	46	ademptis et dentibus	19	46
			instrumenta non levia	17	
			lacesseretur ut ceteri	3	
			vivus exustus est	8	26
$\gamma\zeta$	7	26	fateri compulsus est	8	
	<u>374</u>	<u>199</u>			

	Coll. I	Coll. II			
	374	199			
			remcare permissus est	9	
			continuaré praeceptus est	1	
$\delta\zeta$	4	2	acta vel dicta sunt	1	2
			cadavera tracti sunt	1	
β	1	0	(Tyaneús Apollonius)	0	
$\beta\gamma$	3	1	haec et similia	1	
$\beta\delta$	2	0	(túm apud Náessum)	0	
$\beta\zeta$	1	0	(haec prosecutus est)	0	
	<u>385</u>	<u>202</u>			

Form III.

	Coll. I	Coll. II			
			magna decernebatur	25	
γ	37	55	monstrare pollicebatur	18	55
			altiora meditaturum	9	
			perrumperetur impropugnata	3	
			collibus abdidérunt	284	
δ	235	540	memoria commendarent	197	540
			confidentius inruperunt	51	
			incitatissimo tribuentes	8	
			foedus ut apparebat	16	
$\gamma\delta$	33	43	certabant et dignitate	13	43
			documentis et vindicanda	12	
			felicítatis ut videbatur	2	
$\delta\epsilon$	35	36	rexerat pro praefectis	25	36
			docebimus et aperte	9	
			exercitibus et salutem	2	
$\gamma\delta\epsilon$	4	2	advectae sunt per Catonem	2	
$\gamma\delta\zeta$	0	2	obiecti sunt praeter morem	2	
$\gamma\epsilon$	1	3	fuisse quod evenit	3	
	<u>345</u>	<u>681</u>			

Form IV.

	Coll. I	Coll. II			
γ	18	15	tristium clamitantibus	6	15
			discrimine penetrabile	9	
$\gamma\delta$	<u>6</u>	<u>4</u>	laturus et necessaria		4
	24	19			

	Coll. I	Coll. II		
	24	19		
$\delta\epsilon$	12	4	eminuit ut docebimus	4
$\delta\zeta$	6	2	hactenus super Alpihus obsidia praeter solitum	2
$\delta\theta$	1	5	$\delta\theta$ fidentius absolutus est	3
			$\gamma\delta\theta$ ita ut opinati sunt	1
			$\delta\epsilon\theta$ restituit ut praeceptum est	1
γ	1	0	(possint obseruantibus)	0
$\gamma\theta$	1	0	(commentum excogitatum est)	0
$\gamma\epsilon$	1	1	($\gamma\epsilon\theta$) posse quod ablatum est	1
$\gamma\delta\epsilon$	1	0	(missus est ad Hispanias)	0
	47	31		

On the evidence of the statistics from the second collection the question of the length of the first word in the clausula may be disposed of summarily. In any type of any form the first word may begin either with the accented syllable (as in *nosse confingit*) or with any number of unaccented syllables (as in *perculus abscessit*, etc.). Moreover, there is no indication of any effort to make the first word either balance the last or contrast with it in length. The length of the first word therefore appears to be a matter of complete indifference to Ammianus, and we may dismiss it from farther consideration.

For the 'typology' of Ammianus' clausula, the first point to claim our attention is that there is essential agreement between the interior and the final clausulae.¹ Both exhibit the same types, and, roughly speaking, in the same general proportions. One or two types, to be sure, are somewhat more common before strong pauses than before weak ones, and vice versa; but these are minor stylistic features which we may leave out of account for the present.²

The normal clausula in Ammianus is composed of two words; four-fifths of his cadences are constructed in this way. In forms I and II the only possible two-word types are β , γ and δ , all of which occur. The γ types (*periere conplures*, *properabat intrepidus*) and the δ types (*passibus citis*, *opifex callidus*) are very frequent,

¹ Of course the statistics from Book XXI include the final clausulae there, but they form only a small proportion of the whole, and do not affect the general conclusions drawn from a comparison of the two collections.

² See p. 202.

while the β types (*sol aestimatur*, *Tyaneis Apollonius*) are rare. Of II β the only instance is the one cited, an interior clausula in Book XXI (158. 30): I β is more frequent, with 31 cases in all.¹ The reason for their infrequency is not far to seek. The first word in the β types must be either an oxytone or an accented monosyllable. But there are very few native oxytones in Latin (*adhuc*, *illuc*, etc.) and though the adoption of Greek accentuation in loan-words gave Ammianus a certain number of proper names with the requisite accent (as *Tyaneis*, *Thebais*), even with this addition the number of oxytones at his command was very small. And as for monosyllables, those that naturally bear a strong accent are infrequent (the nouns) and such as are frequent (the auxiliary *sum*, conjunctions etc.) do not ordinarily bear a strong accent except when their stress is increased by special emphasis or sentence-accent.² Consequently combinations capable of producing these types would seldom have suggested themselves spontaneously to Ammianus, and we can say that he made use of them when they occurred to him, without either seeking or avoiding them.³

In III and IV the only possible two-word types are γ and δ ; here again they all occur. But IV γ is very infrequent. The list shows but one case (the sentence-ending *possint obseruantibus*), and I have noted only 17 more in the whole of Ammianus, all of which are interior clausulae.⁴ The type can only be constructed by using a six-syllabled word with antepenultimate accent, and its infrequency must be ascribed in the main to the rarity of such words.

In point of rhythm there is a question regarding the γ types of III and IV that should be raised here, although we cannot settle it. Since

¹ Outside of the collections I note half a dozen cases of II β : they are— I. 17. 29 *urbs venerabilis*; 28. 3 *urbs perspicabilis*; 228. 22 *est supervacuum*; 271. 7 *ad id pertinentia*; II. 223. 28 *rex potentissimus*; 237. 3 *est voluptabile*. They are all interior clausulae: the type does not occur at all in finals.

² As in *iustum quid sit ignorantibus* II. 224. 23. See p. 206 f.

³ It may be that some of the clausulae which I have classified under III $\gamma\delta$ and IV $\gamma\delta$ are really I β and II β : i. e. instead of *felicitatis ut videbatur* perhaps we should read *ut videbatur*. But rather than trust the subjective criterion afforded by my own notion of the probable sentence-accent, I have preferred the objective one of listing under III and IV all cases in which the monosyllable is preceded by a word accented on the penult. Thus *felicitatis ut videbatur* counts as III $\gamma\delta$, while *impendio est formidanda* counts as I β .

⁴ I. 81. 8 *constanti sollicitudine*; 133. 14 *incusari malivolentia*; I. 183. 10; 190. 8; 269. 9; 273. 18, 24; 279. 27; 290. 30; 304. 19; 317. 26; II. 63. 17; 80. 16; 165. 14; 259. 28; 260. 15; 270. 8.

all words of four syllables in Latin must have had a secondary accent on the first syllable, the cadence in δ types would seem to be *collibus abdidérunt, militibus obscuríssimis*. If we might believe that the secondary accent in polysyllables always fell on the second syllable before the main accent (*existimabat, malivoléntia*), the effect of the γ types would appear to be the same. Since, however, it is doubtful if we can make this assumption, we must admit the possibility of a slight discrepancy in cadence between different examples of the γ types (perhaps *magna decérnebatur*, but *altióra méditaturum*). This discrepancy, if genuine, cannot have been very great.¹

Turning now to the three-word clausulae we find that types in three words are made by the use of an atonic monosyllable or dissyllable, and are frequent. Theoretically, a monosyllable may be introduced either between the accents or after the last accent. In the first case the possible types are $\beta\gamma$ and $\gamma\delta$ in forms I and II, $\gamma\delta$ and $\delta\epsilon$ in forms III and IV. In III and IV both of the two possible types occur with equal frequency. Both in I and II the type $\gamma\delta$ is common, while the type $\beta\gamma$ is extremely rare, for the same reason that accounts for the rarity of the simple types I β and II β . As to the introduction of a monosyllable after the last accent, it is virtually impossible in I and III, where the monosyllable would have to be preceded by a trisyllabic oxytone to produce the cadence in a three-word clausula.² Consequently it is not surprising that we find no examples. On the other hand it is quite possible in II and IV, and frequently occurs, giving in II the types $\beta\zeta$ (*haec prosecutus est*), $\gamma\zeta$ (*vivus exustus est*) and $\delta\zeta$ (*cadavera tracti sunt*), in IV the type $\delta\vartheta$ (*fidentius absolutus est*).³

While nearly all the instances of the three-word clausula are occasioned by the employment of atonic monosyllables in the way just indicated, there are a few cases produced by the use of a lightly accented dissyllable. Naturally instances of forms I and II made in this way are very rare. There is no case of I $\beta\delta$ in the table, but I note one good example of it at the end of a sentence (II. 124. 12 *adhuc apud Persas*). Of II $\beta\delta$ there is one instance

¹ See p. 221 f.

² Fictitious examples are *nunc Thebais est*, (I), *optima Thebais est* (III). The caesura would be somewhat more likely to occur in a four-word clausula, (*usus est, ars est*), but does not.

³ Cf. II. 9. 9 *Poliorcetés appellatus est*, a sentence-ending, and two cases of IV $\gamma\vartheta$ which I find outside the collections: I. 279. 27 *parare adsuefacti sunt*; 290. 30 *simul exanimati sunt*.

listed (I. 252. 16 *tūm apud Nāessum*) and another (I. 247. 29 *tūnc apud Nāessum*), which may be unintentional. In III and IV the phenomenon occurs more frequently, and gives rise to two types, $\gamma\epsilon$ and $\delta\zeta$. The $\gamma\epsilon$ types are peculiar in that the dissyllable in each case but one is due to the vocalization of *u* in the relative pronoun. The instances are, in form III: *suspectae adhuc fidei* (I. 247. 14), *relaturi quāe audirent* (I. 7. 5), *explicare quāe poscebat* (I. 135. 26), *fuisse quōd evenit* (I. 140. 15); in form IV *posse quōd ablatum est* (I. 129, 21, a four-word clausula) and possibly *exurgens quān civilit̄er* (I. 261. 15–16). All are final clausulae except the last.¹ Of $\delta\zeta$ I find only 2 cases in form III in my collections, both of which happen to be four-word clausulae (I. 8. 30 *obiecti sunt praeter morem*, II. 191. 21 *inlatum est ante dictae*), and 5 cases of IV (I. 72. 2 *hāctenus super Alpibus*, 124. 31 *obsidia praeter solitum*, 235. 27 *discubuit inter ceteros*, 241. 19 *venaticiam praedam caperet*, 247. 13 *invenerat apud Sirmium*). To these may be added a few cases from the rest of the work: in form III, I. 11. 22. *quicquān geri posset*; 223. 23 *relinquerat apud Carras*; 292. 23 *creverat ultra modum*; 294. 4 *conlapsa est terrae motu*; 328. 28 *gignitur apud Persas*; II. 34. 8 *caelitus posse labi*; 41. 20 *dimicans inter primos* (cf. 172. 13); 43. 14 *arcentia praeter pauca*; 95. 25 *quiescere prope flumen* (cf. 176. 31); 164. 11 *numquān facta fingit*; 269. 9 *alius semet ferret*—in form IV, I. 22. 16 *aliud satis validum*; 130. 28 *egerat praeter solitum*; II. 53. 4 *quaesita sunt licet noxia*; and perhaps I. 219. 25 *magistrum et quosdam alios*.² Notice that while Ammianus freely admits dissyllables with light accent, he is chary of using those with heavy accent.³

¹ For other cases outside the collections see p. 227, list of instances in which the relative counts as a dissyllable.

² Neither *militi quies data* (I. 225. 29) nor *copia data captam* (II. 152. 34) belong here. In the latter phrase Novák rightly takes exception to *captam*; he suggests *deletam*, but I read *compressam* (cōpssam) which is very close to *captam* (V) and *comptam* (G). The other clausula is to be compared with *nocturna quies daret* II. 48. 31, where since the first word is penultimate, the cadence cannot have been III. Both are to be explained as form I, *quies* being pronounced with the accent on the vocalized *u* (*quies daret*, *quies data*). Cf. *quies oportuna* (II. 22. 8) *curatis et quācte* (I. 312. 6); and p. 228 f.

³ In *numquān facta fingit* (i. e. *fingit ea quae numquam sint facta*), in *venaticiam praedam caperet* and the like, the sentence-accent must have raised the stress of the first word at the expense of the second. In *potentissimi regis instar* (I. 312. 21) the preposition appears to bear a heavier accent than its noun.

Turning now to the four-word clausula, we find that there are only 15 examples of it; one in form I (I. 237. 19 *id prae me ferens*), one in form II (I. 146. 17 *acta vel dicta sunt*), 7 in III (5 of the type *obiecti sunt praeter morem*), and 6 in IV, of various types. Since the four-word clausula can be produced only by making use of two atonic words, and since such combinations would naturally occur seldom, we can hardly be surprised at its infrequency.

We have still to discuss the one-word clausula. Though the forms III and IV cannot be constructed in a single word, it is, of course, possible to get I and II with a polysyllable, provided its secondary accent fall in the right place (*archipirata*). But Ammianus certainly avoided such types, and may have avoided them altogether. For with few exceptions the words capable of rendering them are used in the construction of two-word clausulae in other forms, and in most of the few exceptions the text is obviously corrupt.

The only polysyllable that is commonly found before a pause in Ammianus is the word of five syllables with accented penult.¹ In my two collections it occurs 98 times; in 92 cases it is preceded by another word accented on the penult, thus producing III γ. The 6 exceptions are as follows:

- I. 55. 24 *negotium praeterinquiri*—where we need only pronounce *negotium* to get the usual III γ.
 100. 24 *graviter toleraturi*—excise *graviter*, that the sentence may run as it ought, *non sine ultimorum conatu toleraturi*.
 236. 21 *quam celeritatem*—perhaps vocalization of u and shift of accent (*quam*: p. 228).
 244. 19 *trahendumque si reuiteretur*—this should be read as a case of the rare form V.
 II. 183. 21 *accolae Igilgitanum*—V has *gilgitanum*, which would give form III: Forbiger suggests *Igilgitanum*, which would give form VI (*Alt. Geog.* II. 872. 89).
 241. 25 *aemulae temeritatis*—inverting, we get a better re-spension, *alter per Thracias comes, dux alter exitiosus, aemulae ambo temeritatis*.

To these we may add the following list, which comprises all the instances in Ammianus that precede a full stop.

¹ Words of 6 syllables with antepenultimate accent (*sollicitudine*) are always used to produce IV γ (see p. 182); words of 6 syllables with penultimate accent, and of 7 syllables with antepenultimate accent (*circumveniretur, circumvenientibus*) to produce the rare forms V and VI (see p. 168).

- I. 215. 8 *subito remuntiaſſe*—V. *redundasset*: read *redundasse*.
 228. 29 *propositi reverteretur*—V *revertetur*, which should be retained: Löfstedt, *Eranos* 1909, p. 4.
 273. 20 *veniae permitteretur*—a case of synizesis (*veniæ*); see p. 223.
 281. 21 *tempore disserebanus*—V *disseremus*; as the reference is uncertain, the reading should not be altered.
 310. 34 *aliquid praesagiebat*—V *praesagebat*; read *praesagabat* (preferable to *praesagibat*, cf. Neue, *Formenl.* III, 293). The next sentence also ends in III γ .
 II. 51. 28 *fluminis absorbebantur*—V *adorbibantur*; read *sorbebantur*. Cf. I. 162. 35.
 84. 30 *praesidio custodiebat*—read *custodibat*.
 138. 1 *molibus communiebat*—V *commovebat*; read *communibat*, comparing I. 163. 7 (Neue, *Formenl.* III. 317–18).
 162. 21 *agitur et praetercunda*—perhaps we should read *atque* for *et*.
 188. 17 *provincia pervaderetur*—synezesis.

In view of the state of the text in most instances, it seems to me highly unsafe to assert that any of them ought to be interpreted as examples of I without *cæsura*. The reason for the avoidance of this clausula is to be sought in the fact that its first accent was much weaker than the same accent in other types of I, so that it did not produce a cadence satisfactory to the ear.

We find, then, that Ammianus used practically all the possible types of each form, avoiding only the one-word types of I and II. The types that are really common are not many; they are summarized for the sake of convenience in the following conspectus in which the statistics are based on Book XXI.¹

	I	II	III	IV	
	γ 353	γ 202	δ 235	δ 19	
	δ 210	δ 108	γ 37	$\gamma\delta$ 6	
	$\gamma\delta$ 75	$\gamma\delta$ 68	$\gamma\delta$ 33	$\delta\varepsilon$ 12	
			$\delta\varepsilon$ 35	$\delta\zeta$ 6	
	638	378	340	43	1399
All other types	10	7	5	4	26
	648	385	345	47	1425

¹ Clausulae in II with ζ *cæsura* (*vivus exustus est*) and in IV with ϑ (*fidentiſ absoluteſt est*) are here classified on the basis of the main *cæsura* (i. e. II $\gamma\zeta$ as II γ , II $\delta\zeta$ as II δ , IV $\delta\vartheta$ as IV δ).

In the main the common types owe their frequency, the uncommon types their infrequency, to conditions involved in the nature of the language.

QUANTITY.

The tables which stand at the end of this dissertation record the scansion of the clausulae comprised in my collection of sentence-endings.¹ In the face of the returns which they present one would be impelled at first glance to deny that Ammianus observed quantity at all. No form, nor even any type, bears evidence of consistent treatment. On the contrary, each form shows examples of almost every possible variation in metre: in I we find 11 different scansions out of 16 possible to the form, in II 20 out of 32, in III 27 out of 32 and in IV 18 out of 64, in only 31 cases. These facts undoubtedly point to neglect of quantity.² Yet it would be a mistake to infer from them that Ammianus neglected it altogether. The tables themselves supply evidence enough to controvert such an assumption in the predominance of the scansion — ∪ — — ≃ in form I and in the fact that this form has its third syllable long in 834 out of 870 cases.

The attitude of Ammianus in regard to quantity may be precised in these terms—in accented syllables he is entirely indifferent to it, and in unaccented syllables he observes only quantity due to position.³ Let us first take up the proof of the statement that he disregards quantity in accented syllables.

¹ Since Ammianus does not elide, syllables standing in hiatus are credited with their natural length in these tables (e. g. *maritūm adscisci, exemplo adversam*). In conformity, moreover, to the usage of contemporary poets I have marked final *o* short in *moneō, magnitudō, monendō* and the like, final *e* short in *ferē*, etc. The tables have not been carefully revised, because they signify so little. Consequently I cannot vouch for their absolute accuracy, but the amount of error in them cannot be material on account of the care expended in compiling them.

² There is no foundation upon which to base any hypothesis that Ammianus observed quantity solely in responson. On this point the reader can easily satisfy himself: I shall refer only to the passage quoted on page 203 where the responson is more obvious than in any other passage in the Histories. There the clausula *ferē trēcentis* corresponds to *tēmpus extremum*, and *ingressus adultam* (a hexameter-tag!) to *bellorum aerumnas*.

³ The latter statement, strictly taken, is not quite true. But his preference for a syllable long by nature over a short syllable, or vice versa, was so slight and so inconsistently exercised as to be virtually negligible.

QUANTITY UNDER ACCENT.

In Latin words quantity under accent is not as free to vary as it is in Greek. As a result of the penultimate law an accented penult in any word of more than two syllables is bound to be long. Only monosyllables, dissyllables and antepenultimate words can have a short accented syllable. Consequently it is only in these words that our author's disregard for quantity under accent can show itself, and in these words it does show itself unequivocally. For an investigation of the ratio in which short syllables stand to long in monosyllables under clausula-accent, in dissyllables and in antepenultimate words has disclosed that in each case this ratio is normal.

The monosyllables may be quickly disposed of. Under clausula-accent they occur only as the first word in I β , and 5 in 25 are short. So much variation within a single type can only mean neglect of quantity, and since monosyllables nearly always end in a consonant and must therefore make position frequently, there is no reason for believing the ratio of variation to be anything but normal.¹

Dissyllables and antepenultimate words are found in all forms. The following tables show the proportion of short accented syllables that they display in each place in which they occur.

	Dissyllables			
	long penult	short penult	total	% short
I (first word)	155	38	193	20
(last word)	248	87	335	26
II (first word)	29	8	37	22
(last accented word, followed by an enclitic)	2	0	2	
III (first word)	33	8	41	20
(last word)	2	0	2	
IV (first word)	1	1	2	
	470	142	612	23

¹ It is confirmed by the fact that in III $\gamma\delta$ the monosyllable within the clausula is short 6 times in 43, in III $\delta\epsilon$ 6 times in 36. In I $\gamma\delta$ and II $\gamma\delta$, however Ammianus takes care to make the monosyllable long by position: see below.

Antepenultimate Words

	long antepenult	short antepenult	total	% short
I (first word)	143	80	223	36
II (first word)	18	11	29	38
(last word)	100	74	174	43
III (first word)	368	207	575	36
IV (first word)	11	15	26	
(last word)	23	3	26	
	663	390	1053	37

In the dissyllables, leaving out of account the three collocations of which there are only two examples each, we observe that in every position in which they occur the ratio of short penults is approximately the same as the mean ratio of 23 per cent, the minimum being 20 and the maximum 26. Compare with this the state of affairs in the antepenultimate words. Passing over for the moment the figures for IV, we find that the lowest proportion of short syllables under accent is 36, the highest 43, with a mean of 37.¹ Between the highest ratio of short accented syllables in dissyllabic words and the lowest in antepenultimates there is a difference of 10 per cent, and between the two averages of 23 and 37 a difference of 14 per cent. The dissyllables accordingly present a very constant ratio of approximately three with long penult to one with short, while the antepenultimate words present an equally constant but considerably higher ratio of approximately three long accented syllables to two short.

On the supposition that Ammianus chose his words with any reference to the quantity of their accented syllables the constancy of each of these ratios and the fact that they differ from one another cannot be explained. On the contrary, such a result is just what we should look for if we knew him to have observed nothing but accent. For it is obvious that in the Latin vocabulary the dissyllables with short penult must stand in a certain numerical relation to those with long penult, and the words with short accented antepenult to those with long; and it is highly improbable that the numerical relation would be the same in both cases. In any chance collection of dissyllables or of antepenultimate words, the one ratio

¹ In IV the large proportion of short syllables in the first word is due purely to chance; the small proportion in the second word, on the contrary, bears witness to the fact that the ratio is naturally smaller in pentasyllables than in trisyllables and tetrasyllables. See below.

would show itself in the dissyllables, the other in the antepenultimates. The presumption is therefore that the two different ratios which we actually find are these two natural ratios of frequency; and this presumption is not difficult to confirm.

In order to establish the natural proportion of longs to shorts under accent a count in the dictionary is the first means that suggests itself, but not the best, for it does not take into consideration the relative frequency of words. I made a small test, however, on this basis. For the dissyllables I selected the letter F in order to avoid prepositions, which would cause an abnormal proportion of long penults, and found that of the dissyllables beginning with that letter 24 per cent had a short accented syllable. For the antepenultimates I counted three pages at random under each letter of the alphabet, and found that 42.6 per cent had a short antepenult. A better means of proof would be afforded by prose writers, could we hit upon one who did not use *clausulae*.¹ Unfortunately it is only in modern Latinity that we can be sure, without investigation, that quantity is neglected, and I therefore selected Ritschl's Latin speeches (*Opusc.* V, 627-684) for examination. The count was made in the last two or three words preceding each heavy stop, and yielded 267 dissyllables, of which 25 per cent had a short penult, and 358 words with antepenultimate accent, of which 43 per cent had the syllable short. For the dissyllables it was also possible to make a test in hexameter verse, which admits all the varieties of scansion that they can assume. Choosing for this purpose the first Epistle of Horace, I found that 24 per cent of the dissyllables occurring in it had a short penult.

Of course we must not press these figures too close, for they are all of them founded on small counts. But they certainly show clearly that the natural proportion of short accented syllables to long is much lower in dissyllables than in antepenultimate words, and that in the case of dissyllables this natural proportion must be about 3 long to 1 short, in the case of antepenultimates about 3 long to 2 short. Consequently the ratios which we found in Amianus accord with the natural ratios.

To remove any lingering doubt we may pursue the investigation a little farther. Up to this point we have lumped all antepenulti-

¹ Thinking that this might be the case in Tacitus I counted the dissyllables occurring in the chapter-endings of the *Histories* and found a proportion of 36 per cent short! This heavy proportion is abnormal—it is apparently due to his avoidance of the cretic-trochaic *clausula*.

mate words together. Let us now classify them according to length and see what ratio we find in Ammianus in trisyllables, in tetrasyllables and in pentesyllables. The facts are expressed in percentages in this table.¹

	I (first word) % short	II (last word) % short	III (first word) % short	IV (first word) (last word) % short	average
trisyllables	29	33	36	29	34
tetrasyllables	46	50	42	[63]	46
pentesyllables	[38]		11		17

The results are illuminating. Each sort of word shows a different ratio, which is constant no matter in what clausula or in what place in the clausula the word occurs.² Such a condition cannot be due to anything but the working of natural laws of frequency, and we may spare ourselves the pains of seeking confirmation of each ratio from outside evidence.

In all words, then, in which the Latin language admits short accented syllables, we find short syllables occurring in the clausulae of Ammianus in a proportion which shows no trace of intentional tampering with quantities, and which can only be ascribed to the influence of natural laws of frequency. The conclusion therefore is inevitable that Ammianus was indifferent to quantity under accent.

QUANTITY IN UNACCENTED SYLLABLES.

It remains to be demonstrated that in unaccented syllables Ammianus observed quantity by position and neglected vowel-quantity. His regard for position evinces itself in two ways:

- (1) in an effort to *avoid* positional lengthening in the case of the *first* unaccented syllable, and
- (2) in an effort to *secure* positional lengthening in the case of the *second* unaccented syllable.³

The effort to avoid positional lengthening asserts itself in all forms, but only in types with γ cæsura (*nosse confingit*). For in all other

¹ Words of 6 syllables are too few to give a ratio of any value.

² In the two percentages bracketed the count is a very small one (19 tetrasyllables as the first word in IV, 24 pentesyllables as the first word in I). The percentages given under III are based on the largest counts. Statistics as to the length of the first word as well as that of the last are given for all forms in the tables of types, p. 179 ff.).

³ The first of these two observations is Meyer's (*Ges. Abh.* II. 264—265), the second is my own.

clausulae with the exception of I β the first unaccented syllable is the penult of a word with antepenultimate accent (*Claudius Caesar, opifex callidus* etc.) and of necessity is always short, except in rare cases of abnormal accentuation.¹ In I β (*sol aestimatur*) Ammianus might easily have shortened the syllable in question, but as a matter of fact it is long in all 24 cases and long by position in all but 3.²

In types with γ cæsura (γ and $\gamma\delta$ in each form) the tendency to avoid positional lengthening manifests itself clearly. These are the statistics.

Form	does not make position				makes position	total
	Hiatus	Vowel + cons., cons. + vowel	Vowel + 2 cons.	Final -nt, -ns + vowel	cons. + cons.	
I	60	486	38	22	17	623
II	17	133	8	7	8	173
III	21	73	2	3	6	105
IV	2	2	0	0	1	5
	100	694	48	32	32	906

It will be remarked that cases in which a syllable ending in *-nt* or *-ns* precedes a vowel (*redierunt infecto*) are registered among the combinations which do not make position. Although according to classical usage *-nt* and *-ns* should suffice in themselves to lengthen the syllable which they terminate, it is certain that they do not in Ammianus, for when such a syllable precedes the γ cæsura it is customarily followed by a word beginning with a vowel, while when it precedes the δ cæsura in types in which our second rule is observed it is followed by a word beginning with a consonant.³ These syllables are therefore treated exactly as if they ended in a single consonant.

¹ Five cases are registered under III in our table above: I. 28. 17 *Amano disparantur*; I. 43. 21 in *Aegypto trucidantur*; I. 27. 30 *Calycadnus interscindit*; I. 178. 30 *déinceps prohiberent*; I. 130. 32 *déinde sunt progressi*. They show how far Ammianus went in his indifference to quantity.

² This must not be interpreted as evidence of a desire to lengthen the syllable. In this type Ammianus paid no attention at all to quantity. See pp. 193, 196.

³ In the first case there are 27 instances of *-nt* and 5 of *-ns* before a vowel (as in *redierunt infecto*) against 3 of *-nt* before a consonant (*remanent magistris*): in the second case there are 26 instances of *-nt* and 7 of *-ns* before a consonant (as in *nesciens missum*) against 2 of *-nt* and 1 of *-ns* before a vowel (*sufficiens aqua*). The phenomenon is due to the nasalization of *n*.

This point understood, the language of the table needs no further interpretation.¹ And its testimony is extremely clear. We find that when the first unaccented syllable is followed by cæsura it makes position in less than 3 per cent of the cases in form I, less than 5 per cent of those in form II and less than 6 per cent of those in form III. As for form IV there are only 5 cases among the sentence-endings, one of which lengthens the syllable by position. The material is so small that we must bring in further testimony. Among the clausulae from Book XXI I note that of 9 cases of IV with γ cæsura position is made in only one; and in the 17 cases of IV γ cited on page 182 there are only 3 in which the syllable in question is lengthened. Consequently in this form as well as in the others Ammianus' inclination to avoid position manifests itself.

It is plain, therefore, that when the first unaccented syllable came before a cæsura, Ammianus did not like to lengthen it by position. But he had no scruples against allowing it to be long by nature, for it is thus long in 30 per cent of its occurrences. This proportion leaves no room for assuming the slightest preference on his part for a short syllable, since we may ascribe the predominance of shorts to the fact that almost all finite verb-forms have a short final syllable.²

We may note further that Ammianus was very little troubled by hiatus, for it occurs in 11 per cent of the clausulae.

Let us turn now to a consideration of the state of affairs in the second unaccented syllable. The tendency here is not to avoid position, but to secure it. It is not displayed in all forms, but only in I and II, and is not quite universal within these limits.

In I β there is no inclination at all to lengthen the second unaccented syllable, which is short in 12 of the 24 cases.

In I γ and II γ the tendency comes to the surface. Here the syllable follows the cæsura, and is in the one case the first syllable of a penultimate trisyllable (*nosse confugit*) and in the other the first syllable of an antepenultimate tetrasyllable (*semper innocui*). Examination shows that in I γ the syllable is long by position in

¹ The fact that to the ear of Ammianus a syllable terminating in a vowel does not make position before a word beginning with 2 consonants (*venire praecepit*) is in accordance with the prevailing practice of the poets and we need not dwell upon it.

² The proportion is approximately the same in all forms: in I it is 36 per cent, in II 27 per cent, in III 42 per cent. This is as close an agreement as we could reasonably expect.

79 per cent of the cases, long by nature without making position in 17 per cent and short in 4 per cent. In II γ it is long by position in 76 per cent of the cases, long by nature without position in 16 per cent, and short in 8 per cent. To ascertain how far these proportions vary from the natural, I took as the basis for an estimate the penultimate trisyllables and antepenultimate tetrasyllables that *begin* the clausula in various forms and types (as *venire* praecipit, *confluxerit* Roman). Here I found that words like *venire* had the first syllable long by position in 31 per cent of their occurrences, long by nature without position in 34 per cent, and short in 35 per cent, while words like *confluxerit* showed 52 per cent long by position, 20 per cent long by nature only, and 28 per cent short. These ratios may not be very accurate, for they were not based on large counts; but they are accurate enough for our purpose. They show clearly that there is a marked tendency toward positional lengthening of the syllable which we are considering. Though the actual results attained are similar in both forms, the tendency is stronger in I than in II, for in the latter form the natural ratio of syllables long by position is much higher than in form I.¹

We come now to the δ and $\gamma\delta$ types, in which the second unaccented syllable precedes a cæsura (as *passibus citis, vilis et parva*). The two tables which follow will show that position is sought in I δ and $\gamma\delta$ and in II $\gamma\delta$, and that it is neglected in II δ and in all types of III and IV with δ cæsura.

		a) Quantity observed				
		makes position	does not make position			total
		cons. + cons.	vowel + 2 consonants	final -nt, -ns + vowel	vowel + cons., hiatus	
Form						
I δ	201	7	1	14	0	223
$\gamma\delta$	110	0	1	1	0	112
II $\gamma\delta$	46	0	1	0	0	47
	357	7	3	15	0	382

¹ In I γ there seems to be a slight inclination toward conscious lengthening of the syllable before the cæsura when the syllable following it is short, as in *remanerent m̃agistros*. It is not at all consistently carried out, for it is only illustrated in 7 sentence-endings, while there are on the one hand 15 cases in which the short syllable is not preceded by a lengthened one (as in *ruentes aperta, ferienda dederunt*), and on the other hand 10 in which the lengthened syllable is not followed by a short one (as in *tandem perveni*). Yet in view of the fact that each of

		b) Quantity neglected				
makes position		does not make position				total
cons. + cons.		vowel + 2	final -nt, -ns	vowel + cons., hiatus		
Form	*	consonants	+ vowel	cons. + vowel		
II δ	15	4	2	7	1	29
III δ	160	29	7	329	15	540
$\gamma \delta$	35	0	4	7	1	47
$\delta \varepsilon$	12	0	1	22	1	36
IV (all δ types)	12	2	3	13	1	31

These tables require very little comment. At first glance one might be tempted to include III $\gamma \delta$ among the clausulae in which position is sought, inasmuch as it has its monosyllable long by position in 75 per cent of the cases. But the ratio is purely natural, for in I β (*sol aestimatur*) and in III $\delta \varepsilon$ (*poterant nec caveri*) the monosyllable makes position to precisely the same extent.

Our investigations have shown us that under certain circumstances Ammianus made a distinct effort to avoid positional lengthening in the first unaccented syllable and to secure it in the second. It should be mentioned further that in 28 cases of form II with ζ cæsura (*vivus exustus est*) and 6 of IV with ϑ cæsura (*fidentius absolutus est*) the next-to-the last syllable uniformly fails to make position. This fact, however, may be quite unintentional, for even if no attempt were made to avoid position here it would seldom occur.¹ Consequently it is hardly on a par with the phenomena that we have been discussing. We may note, though, that the syllable is long by nature 6 times in II and once in IV. When it is not in cæsura (*semper innocui* etc.), it is bound to be short as a result of the penultimate law.

In forms III and IV the third and fourth unaccented syllables show no trace of any attention to position. But the fact that they are so often both long (*c̄ernēbatur*) and so rarely both short (*tribūentes*) appears to be indicative of a slight abnormality which I should refer to Ammianus' desire to avoid the hexameter close.

these two peculiarities is so rare, the occurrence of both together in so many cases cannot be set down to mere coincidence. It points to a futile desire to avoid the hexameter tag — ~ ~ — —.

¹ The combinations of participle and auxiliary that would naturally occur most frequently do not give position (*tractus, tracta, tractum est: tracti, tractae, tracta sunt*).

Our investigations thus far have been based on statistics from the collection of sentence-endings. If we extend them to the interior clausulae we shall find that there also the same tendencies toward the avoidance of position in the first unaccented syllable and the effort to secure it in the second assert themselves, but to a less extent. It will be of advantage to make this evident in such a way as at the same time to summarize our results for the final clausulae. The estimates for interior clausulae are founded upon Book XXI.

In form I, type γ (*nosse confingit*) when the clausula is final the syllable preceding the γ cæsura fails to make position in 97 per cent of the cases, and the syllable following the cæsura makes position in 79 per cent; when the clausula is interior the respective percentages are 87 and 68.

In I $\gamma\delta$ (*vilis et parva*) final clausulae show the syllable preceding the γ cæsura positionally short in 97 per cent of the cases and the monosyllable long by position in 98 per cent; interior clausulae in 95 per cent and 91 per cent respectively.

In I δ (*passibus citis*) the first unaccented syllable must always be short in virtue of the penultimate law: the second displays positional lengthening in approximately 90 per cent of the clausulae both final and interior.

In II γ (*semper innocui*) the syllable preceding the cæsura fails to make position in 94 per cent of the final clausulae and in 82 per cent of the interior; the syllable following the cæsura makes position in 76 per cent of the final clausulae, and in 72 per cent of the interior.

In II $\gamma\delta$ (*asper et vehemens*) the syllable preceding the γ cæsura fails to make position in 100 per cent of the final clausulae, 94 per cent of the interior; the monosyllable makes position in 98 per cent of the final clausulae and 85 of the interior.

In III γ and $\gamma\delta$ (*magna decernebatur*) the syllable before the cæsura is not lengthened by position in 94 per cent of the final clausulae and in 86 of the interior.

There are only 5 cases of IV with γ cæsura among the sentence-endings, and 9 among the clausulae in Book XXI; one example in each case has the syllable before the cæsura positionally lengthened.

In I β , in II β and II δ and in all types of III and IV without γ cæsura quantity by position plays no part.

We find, then, that Ammianus' inclination to observe quantity by position is nowhere carried out with strict regularity, and that it is considerably less prominent in interior clausulae than in final. The explanation of this fact is that observance of quantity in the

clausulae is subordinated to observance of accentual rhythm. A clausula quantitatively imperfect is now and then (often, it is to be presumed, unconsciously) admitted by Ammianus because it satisfies the accentual requirements, which are more important; and such clausulae are more frequent in the body of the sentence than at its end, because a cadence which precedes a slight pause is much less deeply impressed on the ear than one which comes before a full stop, and any quantitative fault that it may have is therefore less obvious not only to the reader but to the writer as well.

ORIGIN OF THE ACCENTUAL CLAUSULA.

In our study of the nature of Ammianus' clausulae we have determined that his rhythm is based on the recurrence of four accentual cadences:

- I $\tilde{\sim} \sim \sim \tilde{\sim} \sim$
- II $\tilde{\sim} \sim \sim \tilde{\sim} \sim \sim$
- III $\tilde{\sim} \sim \sim \sim \sim \tilde{\sim} \sim$
- IV $\tilde{\sim} \sim \sim \sim \sim \tilde{\sim} \sim \sim$

Though the rhythm in these cadences is primarily accentual it is not purely accentual, for in the first and second unstressed syllables quantity by position plays a certain part in the form of a tendency to shorten the one and lengthen the other.

It is beyond dispute that these clausulae derive their origin from corresponding quantitative forms. The metrical prototypes, in the establishment of which the researches of Meyer and Zielinski have featured most prominently, are

- 1 $\acute{\sim} \sim - : \acute{\sim} \sim$
- 2 $\acute{\sim} \sim - : \acute{\sim} \sim =$
- 3 $\acute{\sim} \sim - : - \sim \acute{\sim} \sim$
- 4 $\acute{\sim} \sim - : - \sim \acute{\sim} \sim -$

The clausula 4 is rare: it is chiefly used, like its accentual derivative, as a means of handling long words, and not all writers employ it. The other three, however, are extremely frequent, and show a steady increase in popularity. Without taking into consideration the modifications of these forms produced by substitution and resolution we find that in entire purity they constitute nearly 45 per cent of Cicero's sentence-endings and 69 per cent of Cyprian's clausulae. Zielinski would interpret all of Cicero's clausulae in terms of these cretic-trochaic forms. However it may be with that theory (for which I do not hold a brief), it cannot be denied that Cyprian's

clausulae are to be thus interpreted, for beside the three pure forms the only clausulae that he uses with any frequency are

$\overset{\frown}{\cup} \cup \cup - : \overset{\frown}{\cup} \cup$	itineris errore
$\overset{\frown}{\cup} \cup \cup \cup : \overset{\frown}{\cup} \cup$	ipse teneatur
$\overset{\frown}{\cup} \cup - : \overset{\frown}{\cup} \cup \cup$	rursus imposuit

These are obviously all modifications of form 1, each produced by the resolution of a single long. All together, the three simple forms and the three modifications of the first form are found in about 92 per cent of Cyprian's clausulae, and are therefore become practically universal in him.¹

The connecting link between these quantitative clausulae and the accentual clausulae in Ammianus is to be found in the coincidence of accent and ictus in the former. Just as through coincidence of accent and ictus the hexameter-close in Latin usually presents the accentual scheme $\sim \sim \sim \sim \sim$, so the vast majority of unresolved metrical clausulae of form 1 present the accentual scheme I, those of form 2 the accentual scheme II and so on. In both cases the coincidence is purely natural in origin: it is a consequence of the penultimate law. A little reflection will suffice to convince the reader of this fact, if he stand in need of conviction. Nearly all the possible ways of putting into words either the hexameter-tag or the metrical clausulae must inevitably give a coincidence of accent and ictus. Combinations of words that do not give it are of such a sort that they would not suggest themselves frequently as a means of reproducing the desired quantities (as *miles gravis armis*). How far the natural preponderance of combinations giving a coincidence of accent and ictus was increased in either case by conscious elimination of combinations which do not give such a coincidence is a questionable point, and one that does not concern us here.

Let us look at the result of this coincidence of accent and ictus in a concrete example. Cyprian's clausulae are metrical, as we have said. But the accentual cadences which they exhibit are as follows.²

I	30 per cent
II	18 per cent
III	26 per cent
A	14 per cent
	88 per cent

¹ The statistics in this paragraph are taken from Zielinski (*Philol. Supplementbd.* 9 and 10).

² The figures are based on the clausulae in the first four tractates, as given in de Jonge's list (*Les clausules métriques dans Saint Cyprien*, Louvain-Paris, 1905).

Now these four cadences are precisely the cadences of the accentual clausula. The cadence A is not employed by Ammianus, to be sure, but it is used to a greater or less extent by many other writers. And that Ammianus' form IV does not appear is owing to Cyprian's avoidance of the metrical clausula 4. These discrepancies represent individual peculiarities in the usage of Ammianus and of Cyprian, which are of little moment in comparison with the fact that in Cyprian we find a great preponderance (74 per cent) of Ammianus' ordinary cadences I, II and III.

Thus the accentual cadences are already present in the metrical clausulae. Consequently, in course of time, as the Latin ear became dulled to quantity, it was chiefly the accentual cadence that was felt. Through lengthening under accent, *facit iniustum* became the equivalent of *fecit iniustum*; through indifference to vowel-length in unstressed syllables *nosci confingit* was not differentiated from *nosse confingit*. On the other hand a clausula like *numquam pie fecit*, which has the same quantitative rhythm as *impie fecit*, produced a different effect because it had not the same accent-rhythm. For the same reason the resolved forms *esse videatur* and *anima poscentes* were dissociated from the pure form *nosse confingit*, and the clausula *semper innocui* was no longer identified with *semper in nocte*, but with *semper innoxii*.

In this way originated the accentual clausulae. Ammianus' four forms represented the four unresolved metrical forms, and they retain a clear indication of their models in the fact that the first unaccented syllable does not make position and that the second does make it. Almost all sensitiveness to quantity is gone in him except for this crude distinction.

The only other writer in the accentual clausula who has been subjected to investigation is Sedulius.¹ He makes frequent use of the cadences I, II and III and a very sparing use of the cadence $\tilde{\sim} \sim | \sim \sim \tilde{\sim} \sim$. This latter clausula, being the accentual equivalent of a resolved form of the metrical clausula ($\underline{\sim} \sim | \sim \sim \underline{\sim} \sim$) should logically have gone out of use, as did the accent scheme of the other resolution $\sim \sim \sim | \sim \underline{\sim} \sim$, but it is conserved, as we have said, by Sedulius and many others. Its retention seems to be solely due to the fact that its metrical prototype was the Ciceronian *esse videatur* clausula which is recommended by all grammarians in chorus from Quintilian on. Although in this re-

¹ These words were written in 1908. Owing to an unfortunate combination of circumstances I am unable to turn to account several dissertations which have appeared since then.

spect and in the disuse of IV Sedulius differs slightly from Ammianus, he is in essential agreement with him in his attitude toward quantity, for he too disregards quantity under accent, and observes quantity by position in unaccented syllables. Failure rightly to appreciate this fact has materially lessened the value of Candel's work upon Sedulius.¹ Yet he himself noted that Sedulius in I γ and II γ freely allows the syllable before the cæsura to be long by nature, but does not allow it to make position.² And there is another obvious peculiarity of the same sort (not noted by Candel) in the clausula $\sim \sim \sim \sim \sim \sim$, where he objects to positional lengthening, though not to natural lengthening of the second syllable in the last word. This is of course a refinement on the practice of Ammianus, and a closer approximation to the ditrochaic close of the metrical form 3. In regard to Sedulius' neglect of quantity under accent I will only point out that in I δ the final disyllable has its penult short in 24 per cent of the cases, and that antepenultimate words have their accented syllable short in 44 per cent of the cases in which they end form II and 40 per cent of the cases in which they begin form III--ratios which correspond to those we found in Ammianus in like words and determined to be normal. These considerations point clearly to neglect of quantity under accent, and to neglect of vowel-length. Ammianus, miles et Graecus, probably could not have written accurate metrical clausulae had he wished to; but Sedulius could, as his *Paschale Carmen* shows. He did not, because he was writing for auditors who would not have appreciated their rhythm.³

¹ *de clausulis a Sedulio . . . adhibitis*, Tolosae, 1904.

² *Op. cit.*, p. 84.

³ In this brief sketch of the origin of the accentual clausula I adhere essentially to the view of Meyer, which was combatted not long since by Schlicher (*Origin of Rhythmical Verse in Late Latin*, Chicago 1900). Schlicher denies that there was any appreciable loss of quantity in Latin except in final syllables, and applies to the accentual clausula an ingenious theory similar to that which he contrived for accentual verse, to the effect that the thesis of the cretic clausula is indifferent, and that in the endeavor to put the uncertain final syllable of a word into this thesis, coincidence of accent and ictus was brought about. But a vital objection to this theory, as De Jonge has pointed out, lies in the fact that the thesis of the cretic is not undetermined. Even Ammianus means to make it short, for that is his object in avoiding position there. And in the face of the evidence from Ammianus I fancy he would hardly care to maintain his advocacy of the permanence of a sense for quantity in Latin. Neglect of quantity in Ammianus is a

CHAPTER II. THE CLAUSULA IN COMPOSITION.

Having discussed in detail the nature of the clausulae which Ammianus employs, we must now give brief consideration to the manner of their use in composition.

Each clausula terminates a group of grammatically connected words, which, in conformity with ancient usage, we may call a kolon. The kola vary considerably from a minimum of the two words necessary to contain the clausula to a seldom-reached maximum of about ten words. Knowing the number of clausulae in Book XXI, we may readily estimate from this the average length of a kolon; it is three-fourths of a line of the Teubner text. Thus the typical kolon of Ammianus corresponds very closely to the ideal kolon of Cicero, the length of which he sets at the length of an hexameter verse.¹ It is natural to be sure, that they should correspond, for the length of a kolon is not entirely dependent upon individual caprice; it is conditioned by the physiological necessity of pausing for breath.

The average length of a sentence in Book XXI is 3.8 lines; therefore in that book there are 5 kola in the typical sentence. There, however, the sentences are short; an estimate in the first six and the last three books shows an average of 5 lines to the sentence. Consequently we may fix the number of kola at 6 or 7.

This must not be construed as a violation of the dictum of Cicero, repeated by Quintilian, that the period should consist of 4 kola.² For the word period (periodus) and its Latin equivalents (ambitus, comprehensio, continuatio, etc.) to Cicero and Quintilian of course do not mean what the Germans call a Periode and what we call a sentence.³ They mean a combination of closely connected kola which may be a whole sentence or only part of one.

condition and not a theory. That it began considerably prior to his time and was general is, it seems to me, clearly enough shown in the attitude of the grammarians toward quantity. The little treatise *De Finalibus* by Servius (K IV. 449 ff.) is nothing but a guide to quantity, which takes the ignorance of the public for granted. It is well worth reading. See also what he says about syllables in his commentary on Donatus (p. 423), especially the phrase *plane quoniam difficilis est deprehensio circa syllabas naturaliter longas, idcirco primum debemus considerare quem ad modum naturaliter proferantur*. There is a great deal more evidence of this sort to be had, and I cannot understand why it has been ignored in the past.

¹ Or. 222.

² Cic. *l. c.*; Quint. IX. 4. 125.

³ For a discussion of the meaning of the word period see Blass, *Rhythmen der asian. u. röm. Kunstprosa*, p. 9 ff.

We have seen that there is no essential distinction in Ammianus between the clausulae which end sentences and those which end interior kola. In both cases the same forms and types occur. We found, however, that in the interior clausulae he displayed somewhat more laxity in his observation of positional quantity than in the final clausulae because it is the final clausulae that dwell longest in the ear. And we noted in passing another difference which was reserved for fuller consideration here, in the point that neither in the relative frequency of the forms with reference to one another, nor in the relative frequency of the various types of each form is there close agreement between the statistics furnished from Book XXI and those from the collection of sentence-endings. As to the frequency of the forms the statistics are here expressed in percentages.

	Book XXI	Sentence-endings
I	45.5	48.8
II	27	11.3
III	24.2	38
IV	3.2	1.8

Following the hint given by this comparison I have examined the facts in Book XXI; they are

	Interior	Final
I	45.6	45.7
II	30	11.1
III	20.9	40.4
IV	3.3	2.6

The relative proportions of the forms are obviously the same in the final clausulae in this book as in the other nine books, though I is slightly less frequent, IV slightly more frequent than usual. But the relative proportions in the interior clausulae are quite different. Form II shows a great increase, form III a great decrease in frequency, while I and IV remain about the same. We find, then, that II is preferred over III before minor pauses and that III is much more favored than II as final clausula. If we pursue the investigation into the typology of these cadences, it becomes clear that the falling off in III as an interior clausula is all in type δ (*collibus abdiderunt*); the falling off in II as a final clausula is marked in all types, but greatest in δ (*opifex callidus*).¹ Furthermore, though

¹ The fact that II clausulae with ζ caesura (*vivus exustus est*) are more common at the end of the sentence than in the interior has no significance: it is simply because verbs are more frequent at the end of the sentence.

I is equally common both at the end of the sentence and within it, the type I δ is in slightly greater favor as an interior than as a final clausula, and, strangely enough, I β (*sol aestimatur*) is more common as a final clausula than it is within the sentence.

Beyond this slight contrast between interior and final clausulae, there is little art superficially discernible in the arrangement and the sequence of the cadences. In general they seem to follow one another almost at hap-hazard, and there is little attempt to group them on principles of balance and contrast. But passages that are more carefully constructed sometimes occur. Far and away the best of these is the lofty flight of rhetoric in which Ammianus epitomizes the rise and decline of the Roman commonwealth (XIV. 6. 3-6). This is well worth quoting in its entirety.

Tempore quo primis auspiciis in mundanum fulgorem	II, I
surgeret ut victura dum erunt homines Roma,	III, I
ut augetetur sublimibus incrementis	III
foedere pacis eternae Virtus convenit atque Fortuna	I, I
plerumque dissidentes,	III
quorum si altera defuisset	III
ad perfectam non venerat summitatem.	III
eius populis ab incunabulis primis	I δ
adusque pueritiae tempus extremum	I γ
quod annis circumcluditur fere trecentis	I γ
circummurana pertulit bella,	I δ
deinde aetatem ingressus adultam	I γ
post multiplices bellorum aerumnas	I γ
Alpes transcendit et fretum,	I γ δ
in iuvenem erectus et virum,	I γ δ
ex omni plaga quam orbis ambit immensus	I γ
reportavit laureas et triumphos,	III
iamque vergens in senium	II γ δ
et nomine solo aliquotiens vincens	I δ , I δ
ad tranquilliora vitae discessit.	I γ
ideo urbs venerabilis	II
post superbas efferatarum gentium cervices oppressas	I
latasque leges	I
fundamenta libertatis et retinacula sempiterna	III
velut frugi parens et prudens et dives	I
Caesaribus tamquam liberis suis	I
regenda patrimonii iura permisit:	I

et olim licet otiosae sint tribus	I
pacataeque centuriae	II
et nulla suffragiorum certamina	II
set Pompiliani redierit 7 securitas temporis;	II
per omnes tamen quotquot sunt partes terrarum	I
ut domina suscipitur et regina,	III
et ubique patrum reverenda cum auctoritate canities	II
populique Romani nomen circumspectum et verecundum.	III

We need not undertake a minute analysis of this passage, for its rhythmical structure is quite apparent. Even in the sentence which opens it and in the two sentences at its close there is more regularity displayed in the disposition of the cadences than is characteristic of Ammianus' ordinary style. But their structure is not nearly so studied as that of the four connected periods which embrace the whole history of Rome. The first of these, describing Rome's infancy, is made up of four kola, while the other three, dealing respectively with Rome's youth, manhood and old age, are of three kola each. While all these kola are about of the same length, it is worth while to notice that in the first period we have three long kola of 13 syllables each, followed by a shorter one of 10 syllables, in the second, two of 11 syllables followed by one of 8, and in the third and fourth a long central kolon of 13 syllables (which in the fourth is broken into two responding kommata) between shorter kola of about 10 syllables. Equally artificial is the responion of the clausulae, all in I until we come to the last kolon of the third period, which is in III (*laureas et triumphos*), the change in rhythm adding emphasis to the kolon, which contains the climax of the whole thought. From this climax through the medium of a cadence in II we are brought back to the old rhythm again, in the two responding kommata and in the close of the sentence. It should be noted, too, that the responion extends even to the types.

This is certainly a remarkable piece of composition: artifice could hardly be carried further. But it stands quite by itself in Ammianus, of whose general style one can get a satisfactory idea from Book XXI.

Though responion is not regular in Ammianus, it is conspicuous. The three more favored clausulae occur so freely that in their case it would be difficult to show this in any way except by referring to the text itself. Form IV, however, being much less frequent, furnishes us with interesting results. Its occurrences in Book XXI are as follows: p. 125, 9; 126, 29; 127, 13, 23; 130, 13, 18; 131, 6, 21, 30, 32; 133, 2; 135, 33; 136, 1; 137, 11, 12, 14, 19; 138, 7, 27;

141, 4; 142, 2, 20; 143, 3, 32; 145, 32; 146, 17, 21; 148, 17; 149, 8; 150, 34; 153, 6, 11; 155, 8, 11; 156, 8; 157, 21; 161, 7, 9, 18; 162, 16; 163, 6, 13; 164, 34; 165, 1, 8, 11, 22.

Instead of occurring regularly once in every page, the cadences are mostly in groups ranging from 2 to 7 clausulae. But there are also numerous more or less isolated occurrences. The two facts point at once to the predominance of resposion in Ammianus, and to the lack of system in it.

Resposion of course brings it about that in short passages of Ammianus' text the relative proportions of the clausulae vary considerably. But any passage of three or four pages will be found to reproduce quite closely the ratios which occur in Book XXI, and which may be mentioned again here as the general norm of use in Ammianus:

I	46
II	27
III	24
IV	3

In proof of this consistency in practice I cite the relative percentages of the cadences in the sentence-endings of the nine books that I have examined. Being final clausulae, they naturally do not correspond to the ratios in continuous composition, but the uniformity which exists in them testifies to a like uniformity in general style.

	XIV	XV	XVI	XVII	XVIII	XIX	XXIX	XXX	XXXI	Average
I	48.8	51.2	56	46.7	44	42	49	53.9	52.1	48.8
II	9.5	12.1	9	14.6	11.2	8.9	11.7	11.8	11.7	11.3
III	41.1	35	34.3	37.5	41.6	46.8	36.2	34.2	33.9	38
IV	0.4	1.5	0.5	1.1	3.2	2	2.9		2.1	1.8

There are discrepancies in these ratios, to be sure, but they are really small—never large enough to indicate any abnormal difference in composition.

The incessant repetition of so limited a number of cadences gives rise to two phenomena which deserve brief comment: the production of unintentional clausulae and of prolonged clausulae. In my text of Book XXI I have signalled the existence of numerous cadences which upon the whole do not seem to me to be intentional because the pauses which they precede are very slight.¹ But there

¹ Naturally I do not maintain that I have drawn the line between intentional and unintentional clausulae with any great accuracy; the definition is, and must needs be, subjective in large measure.

are also cadences in plenty which I have not noted, which do not precede pauses but occur in the midst of a grammatical construction.¹ These cadences certainly cannot be intentional, for they contradict the whole theory of the clausula, which requires that the clausula should terminate a word-group and not break it. They ought, therefore, theoretically speaking, to have been eliminated; they occur probably because Ammianus' choice and arrangement of words was so determined by rhythm at the end of the clause that 'the numbers came' in spite of him where they were not in place. To the same cause we must also assign prolonged clausulae like *pueritiae tēmpus extrémum* and *aetātem ingrēssus adūltam*, and interlocked clausulae like *insidiis fallerētur occūltis* and *celsiōre fiducia repugnarent*. The interlocked cadences are rather rare; the prolonged 'dactylic' rhythms are numerous.

There is great danger of error in ascribing to the clausula any profound influence upon the manner of Ammianus. Inquiry would better be directed into the influence of Ammianus' manner upon the clausula. But for such an inquiry there is as yet too little material to give any satisfactory results.

INFERENCES BASED UPON THE CLAUSULA.

CHAPTER III. MATTERS OF PRONUNCIATION.

While the pronunciation of Ammianus in the main conforms to that which we regard as classical, the clausula reveals many particulars that are important. They are for the most part phenomena either of accentuation or of syllabication, and we shall discuss them under these two captions. The illustrative material cited is drawn from the entire text of the Histories, although, in the case of phenomena which occur frequently, no attempt has been made to register every instance.

ACCENT.

In the construction of Ammianus' cadences phrase or sentence accent, as distinguished from word accent, plays very little part. I find no instances in which this factor produces a shift of word-

¹ The reader will find examples in almost any page of Book XXI.

accent,—such a shift, for example, as appears to occur in *illum patrem* and the like in Plautus and Terence. To its influence, however, we must attribute enclisis and proclisis, of which the examples in Ammianus are frequent but not especially remarkable. As a rule they are monosyllables, including forms of *esse*, prepositions, conjunctions, and pronouns. But proclitic dissyllables, usually prepositions, sometimes occur, as in I. 11. 2 *tunc apud Siden*, II. 41. 21 *dimicans inter primos*, I. 235. 27 *discubuit inter ceteros*. It is noteworthy that Ammianus' usage is not entirely consistent, since on the one hand words ordinarily atonic sometimes bear accent, and on the other hand words that are ordinarily accented are sometimes atonic. Thus monosyllabic forms of *esse* are not uncommon as the first word in I (so I. 9. 18 *scopulis sicut controversa*; 16. 14 *inditum est cognomentum*; II. 224. 23 *iustum quid sit ignoranti*), and *vice versa* we find monosyllabic nouns deprived of their natural accent in cases like I. 167. 27 *sagittariorum pars maior*; 256. 19 *mea mens augurat*; II. 267. 17 *splendore lunari nox fulgens*. So there are many dissyllables that seem to have an abnormally heavy accent (as I. 14. 7 *pube tenuis amicti*; 16. 26 *atque maestitiam*; 235. 13 *erat acturus*; 256. 17 *esse vertendum*; 256. 30 *iter suum praecire*; II. 136. 19 *saevum quidem et rudem*; 144. 9 *ille Cretensis*), and a few that are used as if they were atonic, of which the most conspicuous case is I. 51. 16 *non potest corpus*. Such peculiarities may fairly be ascribed to the working of sentence-accent, although we cannot exclude the possibility that in some cases the stress or the lack of it may be effected arbitrarily in the effort to secure a clausula.

Though the clausula teaches us little about sentence-accent, it brings out a number of interesting points in regard to word-accent. Let us first consider the composita.

In *magisquam* and *potiusquam* we have two compounds not previously recognized. For the one I may cite I. 248. 24 *magisquam consultius* and II. 127. 29 *magisquam severus*: for the other, I. 298. 3 *potiusquam fluit*, 137. 12 *potiusquam simultate*, and II. 41. 8 *potiusquam utebatur*.¹ Another new compound is *etiamtum*, as in II. 162. 4 *etiamtum discordes*, I. 209. 21 *etiamtum infirmium*, II. 247. 11 *etiamtum adorentur* (I. 135. 19; 148. 5; 166. 32; 251. 10; II. 25. 4; 63. 27; 90. 1; 139. 18). But this compound is not entirely crystallized, for not only are there cases in which *tum* has an accent of its own

¹ On the syllabic *u* see below. It is only from cases of this sort that we can get decisive evidence as to the accent of *potiusquam*, for instances like II. 240. 9 *potiusquam timori* might also be read *potius quam timori* (form III).

like II. 39. 7 *etiam tūm increpabat*; 53. 27 *etiam tūm in Italia* and 204. 9 *etiam tūm praepeditūm*), but some in which the two words are transposed in order, as in I. 247. 24 *tum etiam amicum*.¹

No other new compounds have come to my notice in Ammianus, but I find in him valuable testimony in regard to the irregular accentuation of several familiar compounds, which in most cases agrees with the testimony of grammarians.

The grammarians have asserted that the accent of *adhuc* was oxytone, and their statement has been accepted by modern linguists.² Ammianus confirms the fact (II. 124. 12 *adhūc apud Persas*; I. 191. 12 *adhūc imperator*; cf. I. 16. 15; 164. 4; 262. 9; II. 218. 11; 253. 13). But *antehac* has antepenultimate accent (I. 285. 4 *antehac inclytam*), and *illuc* penultimate (II. 191. 9 *illuc ingressus*).

Furthermore the grammarians tell us that in compounds of *-inde* the accent is not penultimate but antepenultimate.³ Here again the evidence of the clausula affords full confirmation, and also shows that *deinceps* falls into the same category. Thus:

subinde: I. 333. 3 *subinde commeantibus*; 241. 21 *subinde praedicabat*; 31. 21 *subinde per aulaeum*; cf. I. 98. 18; 132. 23; 306. 9; 322. 25; II. 14. 6; 55. 22

déinde: I. 130. 32 *déinde sunt progressi*; II. 21. 26 *déinde struebatur*; 126. 20 *déinde Tusciam*; cf. I. 172. 13; II. 132. 20; 218. 27

próinde: I. 214. 3 *proinde iactans* (this word is necessarily rare in the clausula)

déinceps: I. 10. 7 *observatum est déinceps*; II. 208. 19 *déinceps socius*; I. 176. 6 *déinceps multis*; II. 10. 12 *déinceps hortabatur*; I. 178. 30 *déinceps prohiberent*; I. 202. 13 *déinceps arcerentur*.

The accent of *exinde*, however, is ambiguous. In some cases it has an accented antepenult like *déinde* (I. 80. 13 *motus est éxinde*; 110. 23 *éxinde Romam*; 164. 12 *exinde flumine*; II. 137. 25 *éxinde rapuit*),

¹ The word *amicum* here is corrupt: V reads *initium*. J. Hermann suggested *intimum*, which is perhaps the best of many attempts to better the reading, but it is far from satisfactory. It is possible that Ammianus wrote *ἔτιμνον*: on this hypothesis the confusion would have come in early, while the text was still in capitals.

² Lindsay, *Lat. Language*. p. 163.

³ Servius *ad Aen.* VI. 743; Priscian, XIV. 10; cf. also Sommer, p. 103. Seelman (*Ausspr.*, p. 41) is wrong in interpreting Serv. *in Don.* IV. 444. 26 K against the usage, which Servius admits as a fact (*dicimus*), and criticizes theoretically.

whereas in others it has an accented penult (I. 105. 14 *exinde acciderat*; 248. 13 *exinde Iovinum*; 293. 5 *exinde transferri*; 332. 8 *exinde perducti*).

The statement of Priscian that *aliquando* was pronounced with antepenultimate accent is not borne out by the usage of Ammianus.¹ Our author accents the word on the penult: so I. 46. 16 *aliquando nec lacessitus*; 260. 31 *aliquando est visus*; 263. 16 *aliquando audivit*; II. 234. 5 *aliquando contingit*; 242. 16 *aliquando Romanum*.²

We learn from ancient authorities that when the enclitic *-que* is attached to a word, the final syllable of that word is accented even if it be short.³ For this I have noted the following evidence in Ammianus,—I. 196. 3 *pleraque correxit* (cf. 296. 19 and II. 147. 27); 77. 7 *felicitateque correxit*; 101. *indeque cinctorum*; 168. 29 *crudelitateque terrebat*; 179. 15 *telaque dispositis*; II. 176. 28 *sperandaque similia*.

In *patefacit* and *venumdata* we have two verbs with accented short penult. The one occurs only in the clausula *patefacit ingentes* (I. 315. 13), where, however, it is certain, for the sense of the passage excludes the possibility of altering to *patefecit*. It is supported not only by the testimony of Priscian, but by the fact that in this and kindred words there is no such vowel-weakening as in *afficit*, for example.⁴ For the accent of *venumdata* I have found no direct evidence from the grammarians; it occurs in the clausula four times to my knowledge (II. 129. 12 *gentibus venumdata*; 213. 6; 227. 21; 247. 19), and is to be contrasted with *peccumdata* (II. 93. 12 *peccumdatae visae sunt*).

A similar peculiarity is to be observed in the penultimate accentuation of *quolibet* and its different case-forms. Thus I. 107. 30 *quolibet tunc praesens*; II. 147. 1 *interficere cuiuslibet*; 136. 21 *qualibet inventa*; 237. 8 *quolibet occiso*; 236. 16 *transeuntes quolibet*.

Parallel to *quolibet* is *quovis*, which is to be found in the sentence-ending II. 91. 10 *internecivo bello quovis graviozem*. I have not found any other instances of this pronoun in clausula.

To the best of my knowledge *nihilominus* does not occur in Ammianus; on the contrary, *nihilo minus* serves as a clausula in I. 250. 10.

¹ *Inst.* XV. 29; cf. XV. 10.

² Hence II. 105. 21 *aliquando Romanorum* is to be emended into *aliquando Romanum*, comparing the instance last cited.

³ E. g. Priscian, *Inst.* V. 63 and *Part.* 26; cf. Sommer, p. 101.

⁴ *Inst.* VIII. 35; *Part.* 127; cf. Sommer, pp. 102—103.

The most interesting observation of this nature is that in *hoc modo* the accent falls upon the noun, whereas in *huiusmodi* and various other compounds of the sort the noun is enclitic.

hoc modo: I. 162. 25 *paulatim hoc modo*; II. 85. 10 *prudens hoc modo*; 176. 16 *insedens hoc modo*; I. 328. 24 *autem hoc modo huiusmodi*; I. 13. 14 *cogitabat huiusmodi*; 33. 1 *huiusmodi scrutabatur*; 313. 15 *huiusmodi forma est*; cf. I. 148. 10; 236. 13; II. 178. 30

uniusmodi: II. 205. 26 *uniusmodi perferentes*

-modo: I. 248. 5 *quoquomodo corrigendum*; 305. 19 *quodammodo spirant*; II. 49. 6 *tantummodo tenebatur*; 96. 31 *tantummodo vulneratis*

-modum: I. 28. 2 *admodum pauca*; II. 20. 26 *propemodum inaccesso*

Word-accent in Ammianus conforms almost entirely to the classical usage; there are, however, a few noteworthy points which must be enumerated.

Penultimate vowels followed by a mute and a liquid do not take the accent unless they are long by nature. Thus we have *magnae delubra* (I. 285. 18), *visitur aut delubrum* (II. 237. 11), and *longius circumlatrans*¹ (I. 305. 16), but—

tenebras: I. 84. 2 *tenebras adfulsisse*; II. 222. 11 *tenebris amendasset*; 172. 7 *tenebris reptabamus*

latebris: II. 119. 16 *latebris amendarunt*; 197. 11. *l. oportunis*

inlecebris: I. 288. 1 *rapiebatur inl.*; II. 14. 24; 123. 31; 271. 20
integrum: I. 51. 11 *absolvitur integris*; 118. 26; 198. 29; II. 175. 4

muliebri: I. 166. 24 *muliebri sexu*

lugubres: II. 171. 22 *lugubres includebat*

The results coincide again with the testimony of the grammarians, which is opposed, however, to that of the Romance languages. Lindsay is apparently right in assuming that in vulgar speech a short penult followed by a mute and a liquid took the accent, while in educated speech it did not do so.²

The only case in Ammianus of a verb which has shifted conjugation is *oriri* (II. 234. 11 *oritur potest*; I. 16. 19 *adoritur Paulum*; 335. 22 *inde exoritur*; cf. 208. 21; II. 192. 15). This phenomenon, however, is not confined to late writers.³

¹ On the quantity of the *a* in *latrans* see Marx, *Hilfsbüchlein*, s. v.

² Lindsay, p. 164.

³ Neue, *Förment*, III. 253.

In the clausula *fortuito monstravit* (I. 303. 17) we may note the penultimate accent of *fortuito*.

In all perfect forms ending in *-iit* the accent falls upon the penult:

interiit: I. 50. 4; II. 36. 10; 90. 15; 130. 5; 160. 4; 207. 13.

introiit: I. 248. 11; II. 59. 9; 78. 29; 113. 3

abiit: I. 268. 1; II. 139. 23

transiit: II. 116. 31

desiit: II. 36. 3

For this also we have testimony from other sources.¹

Both the perfect subjunctive and the future-perfect indicative seem to have an accented penult in the first and second persons plural; in I. 57. 8 *legerimus* is subjunctive, while in II. 10. 18 *fecerimus* and (31) *egeritis* are indicative. I find no instance of either form with antepenultimate accent.²

There are several cases in which the third person plural of the perfect indicative appears to be accented on the antepenult, not only when the ending is *-erunt*, but also, oddly enough, where it is *-ere*. Thus II. 145. 7 *oppositis coeperunt*; 147. 6 *processerunt longius*; 215. 29 *compulerunt sedes* (where V, however, has *compulit*), and I. 75. 19 *inviae fuere* (cf. II. 121. 2 *fuere gestarum*); II. 109. 17 *intercessere pauci*; 194. 22 *paravere casus*. As it is hardly possible to do away with the cases in *-ere* by changing them all to *-erunt*, we must explain them by the inference that they derive their accent by analogy from that of forms in *-erunt*, which, though exceptional, are legitimate. It is an interesting example of reciprocal influence, inasmuch as the usual long *e* in *erunt* is thought to have come from *-ēre*.

In the case of genitives in *-ius* we may assume that the accentuation varied from one word to another in ordinary speech. Among the words of this sort employed by Ammianus *totius* (I. 102. 23; 154. 27; 160. 31; 211. 11; II. 156. 6) and *unius* (II. 270. 20) have penultimate accent. On the other hand, I find antepenultimate accent in *ipsius* (I. 58. 10; II. 220. 25), *illius* (I. 21. 7; II. 86. 1; 151. 3) and *alterius* (I. 131. 15; 314. 18).

The only marked lapse from correct pronunciation in the direction of Romance development is to be found in the penultimate

¹ Cf. Serv. *ad Aen.* I. 451; Lindsay, p. 132; Sommer, p. 612; Bednara, *Archiv für lat. Lex.* XIV. 350.

² See Lindsay, p. 500 and Sommer, p. 623. In II. 206. 24 *quoque venerimus* is ambiguous, for *quoque* may be pronounced in three syllables (see below).

accentuation of *iudiciolum* in the clausula *non iudicioli est nostri* (II. 119. 30 and 146. 11), which is a distinct vulgarism.¹ But he accents *malleolus* on the antepenult (I. 244. 14; II. 99. 11), and also *Putolos* (II. 147. 9).

The evidence for the accentuation of words borrowed from other languages, which has heretofore been somewhat scanty, is considerably increased by the material which we get from Ammianus, who often employs foreign words in the clausula. Far the greater part of these words is derived from the Greek, as we should expect, or from some other language through the mediation of the Greek. Such words are not affected by the penultimate law, but they bear an accent derived from the Greek.

In support of this statement I shall adduce first a list of words borrowed from the Greek or through the Greek, which according to the penultimate law should be accented on the penult, but are accented by Ammianus on the antepenult.

<i>ἀέριγγας</i> appellamus	I. 127. 1
<i>δοξορτας</i> appellamus	I. 161. 17
Graeco sermone <i>διχόουρις</i>	I. 200. 21
vocamus <i>ἀπόζουσα</i>	I. 201. 1
fragmentis et <i>cylindris</i>	II. 274. 12
architecti ² promittebant	II. 49. 8; cf. II. 18. 15
et prima species luis <i>pandemus</i> adpellatur, . . . secunda	
<i>epidemus</i> , . . . tertia <i>loemodes</i>	I. 176. 8
monstrat <i>amphicyrti</i>	I. 200. 24
<i>heroi</i> consecratis	I. 281. 17
Misopogonem appellavit	I. 294. 19
Epiphania dictitant	I. 233. 22; cf. <i>Befana</i>
operatur <i>Adrastia</i>	I. 42. 5; cf. 269. 10
Antiochiam venimus	II. 58. 13; Antiochiae claudi I. 293. 16;
cf. I. 25. 6; 29. 6; 153. 27; 195. 19; II. 59. 4; 143. 25;	
259. 27	
Alexandria et Hermupolis	I. 331. 2; cf. 329. 22; Alexandriae
contigit	II. 93. 15
Nicomediae pergit	II. 83. 18; cf. 84. 23; Nicomediae clades I.
	125. 11

¹ Cf. *filiole*, *magistro* in Commodian (*Instr.* II. 26. 6, p. 45 Ludwig), *Faviole* and *Liliole* in Venantius Fortunatus (VIII. 1. 42; 3. 43). See Lindsay, p. 164; Sommer, p. 103; Nyrop, *Gramm. histor. d. l. Française* I (2nd. ed.), p. 161, 137, 7; Jespersen, *Lehrb. d. Phonetik* p. 192 § 198.

² From *ἀρχιτέκτων*, not *ἀρχιτέκτων*. V. Saalfeld, *Tens. Italogracc.* s. v.

Apámiam positi	II. 140. 7
prope Basíliam	II. 207. 18
Ábdera visitur	I. 275. 9
Áncyram redit	I. 285. 32; cf. II. 60. 22
Édessam venit	I. 222. 3
Aréthusae captus	I. 51. 18
Calýcadnus interscindit	I. 27. 30
ingressus est Périnthum	I. 266. 23; cf. II. 274. 30; 275. 18;
Apris et Périntho	II. 103. 5
Aégyptum petens	I. 271. 24; Aégypto circumlata I. 306. 1;
cf. 306. 12; 295. 21; 43. 21	
Eúxinus appellatur	I. 281. 7; Eúxino ponto II. 204. 15
sunt in Hellésponthum	II. 246. 17; cf. 85. 2; contentus Helléspontho
I. 160. 23; cf. II. 242. 5	
Cherrónesus est propinqua	I. 280. 30; cf. II. 90. 31
colonia Míletus	II. 126. 9
protentam ad Páchynum	I. 242. 8
contingit et Ábydon	I. 275. 20
est Criumétopon	I. 278. 26
Dárei pater	I. 327. 24.
Séleuci regis	I. 27. 31; Nicátoris Séleuci 325. 32
Aésopi cavillationibus ¹	II. 214. 7
magnus somniabat Aléxander	I. 45. 22; cf. II. 86. 31; rapuissent
Aléxandrum	I. 321. 14; cf. 152. 22; 309. 21; vicum Alex-
andri	I. 119. 25; cf. 321. 20; credatur Aléxandro I. 214. 6
Ménander comicus	I. 257. 23
Miconas videbis et Láchetas	II. 149. 29
apud Plátonem legitur	II. 39. 29
Arachotóscrenem appellatam	I. 335. 29
transiere Thermódontis	I. 278. 19
cognominantur Acóntisma	II. 101. 30; cf. 81. 28
Tios et Amastris	I. 277. 29

These words obviously derive their accent from the Greek: it should be observed, however, that they are emancipated from the working of the Greek ultima law. For instance, the word *cylindris* in being accented on the antepenult not only violates the Latin law because of its long penult but also the Greek law because of its long ultima; both languages (though for different reasons) demand an accent on the penult. We must conclude, therefore, that in such words the antepenultimate accent is brought over from the

¹ See p. 168 ff. regarding this form of clausula.

Greek *casus recti* (cylindrus = *κύλινδρος*), and then retained throughout the Latin inflection in accord with the spirit of the Latin language. This slight concession to the Latin genius is significant, for it indicates that the mode of accentuation with which we are dealing was not peculiar to Ammianus, but was at least more or less general in his time.¹

The next list contains words which Ammianus accents in Greek fashion upon a short penult.

<i>βασιλέα</i> et reliqua	I. 122. 2
ut <i>εὐθύθη</i> Graeci dicimus stultum, et noctem <i>εὐφρόνην</i> et furias <i>Εὐμενίδας</i>	I. 281. 8
metuens tyrannidis ²	II. 106. 9
pansa chlamýde	I. 83. 14
Rhodópen et fretum	II. 253. 7; cf. 101. 25
Anáphe et Rhodus	I. 127. 20
Helícen exurgens	I. 278. 25
Meróe et Delta	I. 298. 17
dicitur Orsilóche	I. 281. 11
portus Acóne	I. 278. 3
Jovis filius et Danáes	I. 28. 5
latitudinem Sauromátas	I. 280. 13; II. 235. 1
memorantur Odrýsae	II. 102. 6
Leontino Gorgia	II. 209. 22
Anaxagóras adfirmat	I. 127. 2; cf. 275. 30
Pythagórae decrevit	I. 69. 16
dicitur et Socrátes	I. 258. 2; cf. II. 146. 14
sollertia Dinocráti	I. 303. 13
idem Arsáces	II. 51. 11; cf. 121. 30
Aristotéles adfirmat	I. 232. 12
Aristoménes e latebris	II. 160. 7
Hermogéne defuncto	I. 241. 4
Asclepiádes philosophus ³	I. 293. 20
philosophus Simonides	II. 169. 19
lyrici Bacchylídis	II. 40. 3
Euripídis sepulchrum	II. 102. 4; cf. Sidon. Apoll. IX. 234
Thucydídes exponit	I. 175. 27

¹ See pp. 218—220.

² The word occurs also in Sedulius with this accentuation: see p. 220, note 1.

³ On the accent of *philosophus* see below, p. 217.

inisse Persidos	I. 328. 16; Persidis I. 28. 24; 319. 4; 321. 6; II. 54. 18; Persidem 74. 17; 206. 11; Perside I. 321. 26
Hesperidas appellant	I. 303. 4
clauditur Maeotidos	I. 276. 23.
Chalcida transmissi sunt	II. 3. 27
Propontidem et Thracias	I. 322. 11; cf. II. 44. 11
insulaeque Stoechades	I. 73. 26
atque Cycladas	I. 275. 2
sunt Symplegades	I. 277. 13
Teredona porrigitur	I. 323. 5

The third list comprises a few words that have an accented ultima.

Thebais adpellatur	I. 117. 17
Copton et Antinou	I. 302. 22
Seston et Callipolin	I. 275. 19
Polorcetés appellatus est	II. 9. 9
Perseus memoratur	I. 28. 4
Tyaneus Appollonius	I. 258. 6

This list is short, but it should be noted that on the analogy of *Thebais* we can postulate nominatives with accented ultima from the oblique cases of such words as *tyrannidis*, *chlamyde*, *Persidis*, *Maeotidos*, *Chalcida*, *Propontidem*, and probably *Teredona*.

We find, then, in Ammianus a great number of instances in which the Greek accent is taken over with the borrowed word. Against these I can set only a few exceptional cases in which the Greek accent is not preserved.

Exceptions are proportionally most frequent among those words which in Greek have an accented ultima. With *Seston* and *Copton* in the last list we may compare the following words.

chóros	I. 279. 12
chamúlcis	I. 119. 26
Théssali	I. 282. 21
Adiabénam	I. 310. 25
lýricus	I. 18. 11
hydraúlica	I. 21. 19
hieroglyphicas	I. 118. 16
phýsicae	I. 118. 29
mýstica	I. 171. 19; cf. 258. 7

In these cases the accent is thrown back, and its place is apparently determined by the penultimate law. But in *Aegyptiaca* (I. 296. 17) and *Constantiacas* (I. 247. 12) it goes back only to the *a*, which is short. This is paralleled by the statement of a grammarian

(*de accentibus liber*: K. III. 525. 27): quae autem habent *c* inter *i* et *u* in paenultimo loco, corripiuntur, ut porticus Gallicus Italicus Alemannicus Romanicus: excipiuntur ea quae habent *a*, ut Taurinacus. The phenomenon is perhaps attributable to a tendency to accent the broader vowel.¹

Against Teredona, in which the accent is probably on the ultima in the nominative, we may set *Amázones* (I. 278. 9: II. 235. 22) and especially *Chalcédona* (I. 267. 12: 272. 10: II. 89. 27), with recessive accent. There is nothing to show how Ammianus accented the nominative in these two words. In *Paphlago* (I. 239. 18) it apparently falls on a short penult: if this assumption is correct, it may be derived from the oblique cases (*Paphlágónis*).² But it is ill arguing from isolated instances.

From our limited material it would seem that only unfamiliar proper names retain their Greek accent when that would fall upon the ultima—that familiar words, and especially common nouns, throw their accent back to a place usually but not invariably determined by the penultimate law.

Ammianus almost always retains the Greek accent when it falls upon the penult or the antepenult. A notable group of exceptions however, is formed by place-names ending in *-ia*, all of which he accents on the antepenult, whether they come from the Greek or not. Thus

Bithynia	I. 37. 34: 276. 5: II. 85. 1
Sicilia	I. 43. 22
Dacia	I. 48. 17: II. 101. 20
Syria	I. 76. 7
Aegyptia	I. 119. 4
Mesopotamia	I. 123. 3: 154. 18: 208. 18
Pannonia	I. 135. 1: 189. 19
Armenia	I. 222. 2
Hiberia	I. 241. 1
Mygdonia	I. 277. 6
Paphlagonia	I. 277. 27
Cilicia	I. 309. 32
Media	I. 311. 22
Assyria	I. 324. 9
Phrygia	I. 324. 25
Arachosia	I. 335. 25
Cappadocia	II. 59. 19

¹ Cf. *iudicium* above, p. 212.

² See p. 171.

Galatia	II. 87. 6
Lycia	II. 87. 10
Asia	II. 125. 15
Francia	II. 208. 22
Thracia	II. 240. 20
Pamphylia	II. 245. 26
Macedonia	II. 245. 27
Moesia	II. 252. 18

This practice is of course due not only to the long usage of Greek names in *-iā* like Mesopotamia, but to their analogy with names purely Latin like Italia, Graecia. It would have been utterly impossible to preserve any rational distinction. The clausula *Thebaidem et Libyam* (I. 302. 17) shows that Libya (*Λιβύη*) belongs in this category.

From *Eusebia* (I. 94. 15; 126. 11; 240. 7), *ecclēsia* (II. 160. 3) and *philosōphia* (I. 326. 14) we may perhaps conclude that not only names of countries but also all other Greek loan-words in *-iā* were accented on the antepenult by Ammianus.¹ No such convenient and sensible rule prevailed in later times—in fact, so great confusion arose that even native Latin words in *-iā* occasionally had penultimate accent.²

There are in Ammianus a few compound words with exceptional accentuation for which the reason is not clear to me:

theólogi	I. 127. 16
philósophus	I. 293. 20; II. 169. 19
lotóphagi	I. 22. 6
galactóphagi	I. 333. 14

Beyond these exceptions I have observed only the following:

Hélena	I. 279. 22
Homérus	I. 296. 32; 276. 6; 257. 27; 334. 15
Milónem	II. 221. 2
Theodórus	II. 163. 5; 169. 1
Nicáea	II. 82. 13; 83. 26; 89. 16; 111. 18

Homerus and Helena may perhaps be accounted for as names known mainly from books and Latinized through long currency in the speech of educated men: they are not quite on a par with names like Alexander, for instance, which on account of its frequency in every-day use could not be Latinized so easily. A Greek slave would probably have answered more readily to Aléxander than to Alexánder. The pronunciation Milónem as against Plátonem may

¹ Cf. K. III. 522. 9.

² E. g. *l'Italie*, from *Italia*.

be due to the influence of the Latin name Milo, but I can see no satisfactory reason for Theodorus. The penultimate accentuation of Nicaea is especially odd in view of the fact that the modern names of the two prominent cities formerly called Nicaea, Isnik in Bithynia (to which Ammianus refers), and Nizza in Italy, both testify to an original antepenultimate accent. We cannot suspect Ammianus of ignorance, for having seen much military service in those parts, he probably had visited the city, and certainly had often heard its name spoken. Can it be due to some whim of his own or of his immediate circle that the name is not derived from the name of the daughter of Antipater, but from the adjective *νικαῖος*?¹

The upshot of our investigations is that words having penultimate or antepenultimate accent in Greek are with few exceptions accented on the same syllable by Ammianus, and that even among words with accented ultima some (apparently such as are less familiar) retain the accent on that syllable.

This result tallies with testimony from two other sources,—from the Latin grammarians and from the language itself.

The grammarians, to be sure, are not all in agreement. Diomed and Servius, followed by many later and lesser lights, hold that Greek words should be accented in Greek fashion when the Greek inflectional forms are preserved, but in Latin fashion when the Latin terminations are used.² This would sanction Ammianus' pronunciation *Persidos*, but not *Persidis*. In his case no such distinction can be drawn, for if we can put any faith at all in the text tradition he uses Greek and Latin forms indiscriminately and accents all alike in the Greek fashion.

But this distinction has the ear-marks of pedantry upon it. The pseudo-Sergius, who gives us the fullest discussion of the question (K. IV. 526. 9–528. 27), is at once more liberal and more trustworthy. His passage is too long to quote in its entirety, though it merits reading as an example of the work of the Roman grammarian at his best, displaying unusually careful observation mingled with a modicum of pedantry. According to him, Greek words when they keep the Greek forms of inflection must retain the Greek ac-

¹ Cf. Steph. Byz. s. v. λέγεται δὲ προλαροζυτότως. εἰ δ' ἔστι Νικαῖος, τὸ θηλυκῶν Νικαῖα. Compare also the fact that Nicaea in Phocis had penultimate accent (Forbiger, *Alt. Geog.* III. 612), and the tradition that Nicaea in Bithynia was founded by people from this latter Nicaea (Memnon in Photius. *Bibl.* 233 Bekker).

² Diomed K. I. 433. 4; Servius in Don. K. IV. 427. 10; 525. 8; *ad Geog.* I. 59.

cent. Similarly, Latin words inflected after Greek models must be accented as their models are accented; for instance, *Scipiades*, *Memmiades* with stressed penult. But Greek words taken over into the Latin inflectional system may be treated in two ways; they may be accented either on the Greek basis, as *aëris*, *aethëris*, *Évander*, *týrannus*, or on the Latin basis, as *áeris*, *aëtheris*, *Evánder*, *tyránnus*. But although the Greek system may be followed at will, it must be used correctly if at all: *in quibusdam enim nominibus licet videre plerosque, recti casus ambiguo tenore deceptos, mendose oblicos proferre, ut qui in patrico casu Evandri et tyranni primam syllabam acuunt potius quam mediam, nullam secuti rationem*. This grammarian, then, freely concedes the propriety of accenting Greek loan-words in Greek fashion as Ammianus does, and even acknowledges, though only to censure, the practice of carrying antepenultimate accent through the inflection regardless of the quantity of the final syllable.

Donatus and Sergius go even farther than our unknown, for they no longer admit a choice between the Greek and the Latin basis of accentuation, but insist upon the Greek: in the words of Sergius (K. IV. 483. 29) the rule is stated, *Graeca autem suis accentibus promuntianda esse noscamus*.¹

It has seemed best to me to dwell upon the precepts of the grammarians at some length in order to bring out the value of the passage in the pseudo-Sergius, which has heretofore received little attention. The evidence of the language itself may be despatched briefly.

A certain amount of information as to the pronunciation of loan-words is obtained from the late poets, in whom we find false quantities which can only be due to Greek accentuation. For example, Venantius Fortunatus employs scansions like *Cyclādas* (and often *-ādes*, *-ādis* and the like), *Arātus*, *emblēma*, *problēma*, *idōlum*.² But the bulk of the evidence is afforded by the Romance languages, in which the rule holds that words introduced into Latin from the Greek retain the Greek accent in their Romance derivatives, except when the Greek word was oxytone.³

In a general way, then, we learn nothing from Ammianus that is startlingly new. His testimony is chiefly valuable because it emphasizes with enormous weight a feature of late Latin pronun-

¹ Donatus (K. IV. 371. 27) says, *sane Graeca verba Graecis accentibus efferimus*. This is quoted from Diomed verbatim, but the significant proviso of Diomed, *si isdem litteris enuntiaverimus*, is left off.

² See Leo's metrical index.

³ Meyer-Lübke, *Roman. Gramm.* I. p. 34: *Gramm. Storico-comp. della Ling. Ital.* p. 84.

ation that we have been inclined to overlook, and because it shows that this accentuation was not confined to vulgar speech, but was in vogue in the best circles as early as the fourth century.

It would be beyond the scope of this treatise to consider how much older than Ammianus the custom of Greek accentuation may be. In any case such an investigation would bear little fruit at present, owing to the paucity of data. Further study of Latin prose-rhythm may eventually help to solve the problem.¹

We come now to the matter of loan-words derived from languages other than the Greek. In the lists of Greek words given above a number of words like *Calycadnus* are cited, which were borrowed from some other language through the medium of Greek: their treatment is of course in no wise different from that of pure Greek words. So in *Lárandá* (I. 11. 10) and in *Artogérassa* (*Ἀρταγῆρσαι*: II. 123. 18) Ammianus' accent agrees with the Greek. The curious name *Caenos Gallicanos* (I. 38. 1) evidently is influenced by the Greek: it may be corrupt, for *Gallicanus*, with which it appears to be connected, uniformly has an accented penult in Latin (I. 201. 21: II. 60. 7; 228. 15). *Baráxmalcha* (II. 5. 24) and *Naármalcha* (II. 6. 24; 21. 29) are not to my knowledge mentioned elsewhere, so that we are ignorant of the accent which they bore in Greek. How Ammianus pronounced Amida is uncertain, for we find both *Amída* (I. 168. 2) and *Ámida* (222. 6). Perhaps he was uncertain himself in the matter. In *Amáno* (I. 28. 17) and *Naessum* (II. 71. 13; I. 246. 12; 247. 30) Ammianus accents the antepenult, whereas in Greek the accent is certainly on the ultima in the one (*τὸ Ἀμυρόν*) and probably in the other (*Ναυσόος*). The pronunciation of *Abarne* (I. 167. 10) with antepenultimate accent is paralleled by the Greek form *Ἀβαρόρος*, but the word itself is a transliteration of *Ἀβάρωνη*. A similar thing occurs in *Bézabde* (I. 253. 18; 222. 16), a transliteration of *Βηζάβδη*. Finally, I may cite *Gálatae* (I. 68. 18; II. 60-61) *Sármatae* (I. 136. 18; 21; 32; 137. 11; II. 198. 7), and *sátrapa* (I. 181. 2; II. 51. 19; 36. 32; 121. 12). In how far any of these words may derive its accentuation from the language in which the word itself originated I cannot attempt to say.²

¹ It may be noted here that in Sedulius the words *Cycladas* (Huemmer p. 171. 11) and (in the oblique cases) *tyrannis* (p. 210. 11: 222. 19: 253. 10) have the Greek accent (cf. Candel p. 87). No other loan-words occur in the clausula with him, except perhaps *Esaias* (p. 274. 4).

² On *satrapa*, however, see Seelman, p. 49. On a previous occasion (*Rhein. Mus.* 1907, p. 159) I have hinted that the accent of *rumpia* in Latin may possibly be Thracian.

Ammianus of course employs many loan-words which are in no wise connected with the Greek. To a specialist a study of the accentuation of these words might reveal much. I shall cite only a few which have seemed to me in one way or another especially interesting.

Hánnibal I. 285. 3; Hannibálem 156. 14	
Sáxones II. 151. 24; 152. 12; 222. 13; Sántonos I. 73. 18	
Vásatae I. 73. 19; in Ausonius Vasátes (III. 5; XI. 2. 4; XV. 26. 8)	
Antennácum	I. 147. 32 (Andernach)
Haemimontum	II. 90. 10
Vagábanta	II. 161. 9
Dibaltum	II. 253. 29; 264. 16
Alathéus	II. 45. 5
Arinthéus	II. 71. 22
Dagalaífus	II. 15. 5
Frigéridus	II. 248. 25; 249. 4
Richomères	II. 252. 10
Libinonem v. p. 132: uncertain	
Sáphrax, Sáphracis	II. 264. 28
Támsapor I. 90. 23; Tamsápore I. 155. 15; Sápori I. 123. 23; but Sapórem 212. 9	

Some of these examples show an accent which does not accord with the penultimate law and which is probably influenced by a foreign system. In dismissing them from consideration we may quote Sergius (K. IV. 483. 29 ff.): *in barbaricis nominibus nulla sui ratione sunt, sed quali volumus sane non aspero proferamus accentu:* which probably means no more than that Sergius could see that the penultimate law did not hold, and in the lack of any tangible system could only refer his readers to good use.

Before leaving the subject of accentuation we should note that Ammianus does not give us any light on the important question of secondary accent, for as we have seen already, he avoids the use of the one-word clausula, which alone could be of any assistance to us in this connection.¹

There are two considerations, however, that point to the conclusion that the secondary accent must have been light. In the first place Ammianus is reluctant to admit two dissyllables (*parva manus*) as the equivalent of a tetrasyllable (*postulerunt*) in the close of form III.²

¹ See p. 185 ff.

² V. p. 184.

Secondly, if it must be conceded that certain pentsyllables had their secondary accent on the first syllable whereas others had it on the second, this would mean that there is a slight disagreement between different clausulae of form III, type γ , some presenting the scheme $\sim \sim \sim \sim \sim$ and others the scheme $\sim \sim | \sim \sim \sim \sim$. Now I find no inclination evinced by Ammianus to avoid this hypothetical difficulty; there are no signs that he made any attempt at all to pick and choose between pentsyllables in the construction of this cadence. It follows, therefore, either that all pentsyllables had their secondary accent on the same syllable (which does not seem in the least likely) or that the discrepancy in the location of their secondary accents did not bother Ammianus,—in which case the secondary accent must have been light.¹

SYLLABICATION.

Under the head of syllabication we may first consider the matter of elision and hiatus, which can be summarily disposed of. A glance at the text of Book XXI will show that Ammianus admits hiatus with great freedom. Under certain circumstances, of course, his desire to secure length by position bars it out: for example, he would not admit *praecipue artis* or *Caesarem absens*. In such clausulae, however, it is not the hiatus that is objectionable, but the failure to make position. Wherever a syllable preceding caesura is not required to make position, it may stand in hiatus, as in *diademati utebatur, cogitatione intenta, eorum ecclesiam* etc.² Elision and ecthipsis are not employed at all.

Aphaeresis appears to occur in the following clausulae.³

¹ V. p. 182—183.

² V. pp. 192, 195. The statistics there given show that in clausulae with γ caesura hiatus occurs in about 10 per cent of the instances, whereas in those clausulae with δ caesura in which the δ syllable is not required to be long it occurs in about 3 per cent. This discrepancy can hardly be attributed to a desire to avoid hiatus in δ clausulae: in the one case (*cogitatione intenta*, etc.) it is the last syllable of a penultimate word that is affected, in the other (*diademati utebatur*) the last syllable of an antepenultimate word; hence we could not expect the proportion of hiatus to be the same in both.

³ In Ammianus there is no reason to assume that when the auxiliary is the last word it stands, as it were, extra metrum and does not form part of the clausula. Wherever it occurs last it gives a regular clausula

Rigomagum oppidumst	I. 80. 11
Aquiloni obnoxiaſt	I. 167. 6
interim conſentaneumſt	I. 287. 29
Persidos Gedroſiaſt	I. 336. 1
velut ſolariumſt	I. 337. 2
properare diſpoſitust	II. 260. 13
cedidiſſe exiſtimatust	II. 271. 7
Tritumſt quadriduum	II. 48. 8

These examples are hardly numerous enough to establish the use of aphaeresis beyond doubt, but it should be pointed out that while cases in which it apparently *must* occur are rare, there are many in which it may occur. I refer to clausulae like *vivus exustus est*, *fidentius absolutus est*, which may be classed either without aphaeresis under forms II and IV respectively or with aphaeresis under I and III, and also to a few clausulae like *dispositum est consummato* (II. 195. 25), which may be read either *est consummato* (I β) or *dispositumſt consummato* (III δ).

Of syncope I find only one example: in the clausula *exempta nunc valida sunt* (II. 138. 20) we must assume that *valida* was pronounced *valda*.¹ It may be that in *stivam adprehendit* (I. 14. 10) we have another case (*adprendit*), but there the clausula is uncertain.

Most of the phenomena which we have to deal with under the head of syllabication are cases either of synizesis or dialysis—that is to say, either of diminution in the normal number of syllables in a word caused by the transformation of vocalic *i* and *u* into consonants, or conversely of increase in the normal number of syllables caused by the transformation of consonantal *i* and *u* into vowels.

Examples of synizesis are given in the following list.

-ti etiam	I. 268. 5; II. 142. 21 (cf. Consentius 395. 3)
negotium	I. 55. 24
gignentium	I. 332. 5
repugnantia	I. 254. 10
reverentiam	I. 246. 25
laetior	II. 83. 11
Terentio	II. 124. 8
notitia	II. 171. 22
indicantia	II. 218. 7

of form II (*vivus exustus est*) or of form IV (*fidentius absolutus est*), except in the cases of aphaeresis here cited and in *exempta nunc valida sunt* (II. 138. 20), where I assume syncope (*valda*): see below.

¹ But there are cases in which this word has the normal trisyllabic pronunciation: cf. *validus et castellis* I. 30. 5; *validis iungeretur* II. 243. 7.

-di	obsidijum	II. 20. 29
-ci	provincia	II. 188. 17; perhaps II. 72. 3
-si	perpensius	II. 73. 16
-gi	regius	II. 77. 26
-li	alia	II. 216. 22; 233. 5
	melioris	I. 77. 14
	intellegibilium	I. 199. 6
-ri	Syriis	I. 161. 4
	imperium	I. 305. 2
	memoriae	II. 176. 20
-pi	Aethiopia	I. 28. 5
-chi	Antiochiam	I. 185. 9
-cu	promiscue	II. 247. 3; promiscuae I. 76. 9

These cases do not call for extended comment, since the phenomenon which they exemplify is already well known from the occasional practice of the poets, the testimony of the grammarians and the evidence of the Romance languages.¹ It is remarkable only that instances of synezesis are relatively so infrequent in Ammianus.²

Examples of dialysis are much more common. I submit first a number of instances in which intervocalic *i* appears and counts as a syllable.

Traianus II. 203. 25; 248. 12; 249. 8; 260. 1

Troia I. 279. 21³

aiunt I. 232. 3; 243. 21

Aquileia I. 247. 20; 248. 15

Pompeius I. 87. 4; II. 189, 24

Fonteius I. 75. 10

plebeius I. 232. 15; II. 98. 19.

eius I. 258. 31; II. 90. 8

This pronunciation of intervocalic *i* is occasionally, though rarely, exemplified in the usage of the poets.⁴ In Ammianus, however, not

¹ See Müller *de Re Metr.* p. 249 ff.: Lindsay, p. 142 ff.: Sommer, pp. 144, 145.

² It is possible that some cases which I have listed under forms II and IV (*adulatione flagrantium: decerneret in planitie*) should be read with synezesis as I and III. But I have preferred not to assume it when unnecessary.

³ Priscian K. II. 287. 3 classes *Troia* with *Italia*, *Phrygia*, *Lydia*, etc. Cf. *Part.* K. III. 467. 12.

⁴ In pure Latin words it is very rare: see L. Müller, *de Re Metr.* p. 264. Harper's *Lexicon* (and others) register *Pompejus* (*trisyl.*) or *Pompeius* (*quadrissy.*), *plebeius* (*-ejus*) and *Fonteius*—on what grounds I know not.

only does it occur freely, but it is the rule rather than the exception. At least we may safely assert it to be the rule in the words *Traianus*, *Pompeius*, *plebeius*, *Aquileia*, *Troia*, *Fonteius*, for the clausulae cited, in which *i* counts as a syllable, are the only clausulae in which they occur.¹ But in the clausula *ut aiunt in flammam* (II. 131. 4) *aiunt* has consonantal *i*, *eius* often has it (e. g. I. 235. 2; 264. 6; II. 20. 22; 35. 28; 91. 3; 99. 1), and *maius* occurs several times with consonantal *i* (I. 80. 25; II. 45. 31; 136. 7), but not to my knowledge with syllabic *i*. Furthermore, intervocalic *i* seems to be always (except in *Traianus*) consonantal when it is pre-tonic; thus

aiebat I. 94. 5; II. 175. 14 aiebant I. 318. 22

maiora I. 23. 28 maiore I. 90. 2 maiores II. 145. 18

proiecit I. 116. 28

eiecat II. 19. 30

seiuñctum I. 119. 25

Since the syllabication of *i* regularly appears in certain words, it follows that we are dealing not so much with a metrical expedient on the part of Ammianus as with a characteristic feature of his ordinary pronunciation. Is it peculiar to him, or does he share it with his times? Lack of positive information as to the pronunciation of his period precludes our answering this question definitely, but it may be pointed out that Ammianus was a Greek, and that precisely this peculiarity was noted by Consentius as a fault in the pronunciation of Latin-speaking Greeks.²

Coming now to the instances of the syllabication of *u*, we may remark first that the word *belua* is always a trisyllable in Ammianus (I. 15. 11; 283. 30; II. 32. 13; 46. 31). In this, of course, he agrees with classical usage.

After *s* in *suesco*, *suadeo* and the like *u* is always syllabic.

süesco I. 89. 15 adsüesco I. 137. 19; II. 232. 28

adsüetus, consüetus I. 11. 20; 88. 8; 113. 1; 136. 31; 271. 2;
II. 112. 19 etc.

adsüefactus I. 269. 26; II. 38. 16

süadeo I. 124. 23; 308. 31; 318. 17; II. 247. 8; 262. 21

süasorum I. 215. 15

A fairly extensive search in the poets for an instance of the quadri-syllabic scansion of *Pompeius* has not proven fruitful. For *Troia* see Sen. *Troad.* 824, 853.

¹ Except those in which the word containing *i* comes last and which are consequently indecisive; for example, *ventum est Aquileiam* (I. 49. 31) may be read either as III or IV.

² Consentius K. V. 394. 11 ff.: Lindsay p. 45.

In the usage of the poets *suesco* not infrequently is trisyllabic, *suadeo* occasionally.¹ It is not surprising, then, that Ammianus should make use of this pronunciation, but very surprising that he should use it always.

At once the most wide-spread and the most striking phenomenon of this nature is that *u* may count as a syllable in the combination *qu*-. Though the following list of instances is long, it is by no means exhaustive. The words cited are classified for the sake of convenience into three groups according as *qu* heads a post-tonic tonic or pre-tonic syllable.

Dialysis in post-tonic syllable

aqu ^u is undabundis	I. 127. 1
aqua ^u e furtim	I. 177. 13
aqu ^u is et externis	I. 280. 4
equ ^u is et morigeris	I. 134. 15
equ ^u is concidit	I. 318. 11
equ ^u i terrebantur	II. 32. 5
equ ^u os aut aurigas	II. 145. 15
equ ^u is velocissimis	II. 201. 8
equ ^u is evolarunt	II. 244. 2
antiqu ^u m timens	I. 242. 27
antiqu ^u am sobolem	I. 279. 16
antiqu ^u a sed deserta	I. 303. 2
longinqu ^u a pertimescens	I. 64. 18
longinqu ^u a formidabat	I. 236. 7
aequ ^u m nec laudari	II. 57. 9
aequ ^u m nec sileri	II. 180. 3 ²
propinqu ^u o convectari	II. 185. 13
obliqu ^u e tenebantur	I. 218. 31
sequens Lunae	I. 295. 29 (cf. I. 71. 18; 79. 6)

(enclitic -que)

legibusque discrepantes	I. 72. 7; cf. 86. 9; 168. 9; II. 236. 2; 245. 28; 256. 22; 268. 26 ³
uterque etc.	I. 75. 26; 230. 8; 252. 17; II. 15. 17; 17. 2
quisque	I. 286. 7; II. 4. 30
plerique	I. 28. 13; 36. 17; 331. 13; II. 16. 32
usque	I. 286. 4; II. 110. 16

¹ With reference to *suadet* see also Serv. *ad Aen.* I. 357 *secundum naturam duae sunt syllabae, sed multi trisyllabum putant.* Cf. Lindsay, p. 53.

² This justifies *aequum nec taceri* I. 207. 11, where *aequum* is inserted by Gelenius.

³ Only a few instances out of many score are here cited.

quoque II. 143. 25; 206. 24

ubique II. 274. 24

(enclitic -quam)—

quisquam I. 16. 32; 128. 28; 145. 16; 146. 11; 154. 6; 231. 22;
258. 17; 272. 1; 281. 18; 286. 31; II. 265. 16

perquam I. 139. 5 (p. gnarus) = 147. 20 = II. 104. 12 = 126. 31 =
190. 18; I. 260. 29 (p. scientissimus) = II. 2. 21; II. 50. 25
(p. oportunum) = 214. 30; I. 15. 30; 185. 28; 331. 1; II. 167.
31; 235. 10 (trissyllabic in all the cases that I have found)

umquam I. 14. 14; 91. 7

numquam I. 15. 25; 70. 21; 167. 13; 260. 5; 325. 6

nusquam I. 300. 30; usquam 319. 30

potiusquam I. 298. 3; cf. I. 65. 24; 124. 13; 137. 12; II. 41. 8

Dialysis in tonic syllable

casu propinquabant I. 11. 13

urbi propinquaret I. 91. 22

ambitioso propinquantis II. 104. 11

editum aequabant II. 14. 20

celsitudinis aequatae I. 179. 20

ominis loquamur II. 144. 22

Pannonias et Quadi II. 71. 1; cf. 216. 32; 239. 30; I. 134. 5

divisa quattuor I. 72. 24

modis quattuor I. 127. 17

ambigerentur quaedam I. 32. 27

membra quaedam I. 123. 28

opinantur quidam I. 137. 14

(relative pronoun)

relaturi quae audirent I. 7. 5; cf. 99. 24; 135. 26; 218. 10;
277. 17; II. 16. 11; 162. 18; 207. 6; 219. 13

exposuisse quod elegi I. 65. 26; cf. 66. 13; 140. 15; II. 61. 23

discant qui ignorant I. 119. 7

iste quem videmus I. 94. 3

adventanti quas petebat II. 214. 21

pacem quam poscebant I. 137. 6; II. 58. 18

nocitura quam delictis II. 125. 8; cf. I. 66. 30; 261. 16

Dialysis in a pretonic syllable

recreati et quiete I. 11. 11; cf. 99. 18; 152. 4; II. 199. 14

nimio quassatus II. 21. 24

peritos quaeritabant I. 173. 6; cf. II. 45. 9

regale quaerebatur I. 32. 18; cf. 292. 31

iusta quērelarum I. 130. 4; II. 195. 14
 tumultuando quērebatur I. 288. 31
 eum sequēbatur I. 98. 16; cf. 178. 21

Combination of dialysis in tonic syllable with shift of accent

quies data I. 225. 29
 quies daret II. 48. 31
 quies dedit II. 189. 29
 quies parta II. 115. 17
 quies prima II. 193. 12
 quies oportuna II. 22. 8
 quibus inhiabant I. 269. 26
 quibus sperabatur II. 98. 21
 quibus petebantur II. 273. 20
 quibus habitant II. 234. 8
 quidem sed deformibus II. 233. 12
 quidem aliquotiens I. 247. 31 (p. 146. l. 27)

Although this phenomenon is frequent, it is not constant like the vocalization of *u* in *suesco*, *suadeo*. In the collection of 1811 sentence-endings which has often heretofore supplied us with statistics there are in all 71 clausulae in which a word containing *qu* appears.¹ In 35 of these clausulae the *u* counts as a syllable, while in 36 it does not. On this basis we may conclude that in general *u* is syllabic in about 50 per cent of the instances in which it follows *q*. It should be pointed out, however, that this is merely an average, and that the ratio is not the same for all words.

In *reliquus* and similar words syllabication does not take place at all, for the manifest reason that it would be impossible without a prior shift of accent from the antepenult to the penult. With this exception *qu* may count as a syllable, as far as I know, in any word, no matter what position it occupies in the word. The relative frequency with which it so functions in any given word depends upon the word itself rather than upon the position of *qu* in the word. In some words syllabication is optional, while in others it is the rule. It is optional in *-que*, occurring in about half the cases. In pronouns and adverbs ending in *-quam*, in *potiusquam* and the like, it is very nearly universal, for out of 12 clausulae containing such words, *-quam* counts as a dissyllable in 11. The relative pronoun is oftener a dissyllable than a monosyllable. Syl-

¹ This does not include clausulae like *sufficiens aqua*, in which the *qu* follows the last clausula-accent. In these cases either pronunciation would give a regular clausula.

labication is certainly the rule in adjectives like *aequus*, and is universal in the nouns *equus* and *aqua*. It is universal also in *quies*, both in the nominative, where it is combined with a shift of accent (*quies*) and in the oblique cases (*quiete*). In some other words, such as *Quadi*, *quattuor* and *querela*, it seems to be universal, but they do not occur often enough to conclude this with certainty. In *quaeritabat*, in *sequebatur* and in *propinquabant*, among other words, syllabication is optional.

So unusual is this feature of the pronunciation of Ammianus that at first it seems almost incredible. But it is certain beyond all peradventure, inasmuch as the strength of the evidence which supports it is in no wise conditioned upon the validity of the hypothesis that all of the clausulae in Ammianus were originally 'regular.' Even if we reject that hypothesis, we must still admit that 'irregular' cadences are very infrequent and exceptional. This admission amply suffices to establish the point in question, for clausulae such as those cited above are too frequent to be classed as 'irregular.' The truth comes out unequivocally if we look at the matter in the light of statistics. In 1811 sentence-endings there are 22 which, taking Gardthausen's text as it stands, unquestionably present irregular cadences, and, as we have just seen, 35 which become irregular unless the syllabication of *u* after *q* be admitted. To count these 35 clausulae as irregular would not greatly alter the relative status of the regular and the irregular cadences. But it would bring it about on the one hand that irregular cadences, though constituting but 3 per cent of the total number of clausulae, would occur in 50 per cent of the clausulae which contain the combination *qu*, and on the other hand that clausulae containing *qu*, though amounting only to 4 per cent of the total number of clausulae, would form 60 per cent of the irregular cadences. It is plain, therefore, that to avoid creating an inexplicable abnormality we must admit that all or nearly all the apparently irregular clausulae containing the combination *qu* are in reality regular. And they cannot be regular unless *qu* counts as a syllable in them.

Not only is the principle certain in itself, but there is ample justification for applying it wherever its application will make a cadence regular. On this point it will take but little reflection to convince the most sceptical. For instance in assuming, in order to explain a single clausula,¹ that *quin* counts as a dissyllable, we are supported by the analogy of the relative pronoun. If *quod* may so count, why not *quin*? And in asserting that *quod* may so count,

¹ I. 159. 3 *afuit quin caperer.* v. p. 175.

we are governed by the fact that the ordinary pronunciation of *quod* would create an abnormally large number of irregular cadences containing this word—a fact that hardly calls for proof, as it should be evident merely from the number of instances cited in the list above. But to remove any possible doubt we may point out that in the collection of sentence-endings the relative occurs in only 8 instances, of which 4 are irregular if we give the word its usual pronunciation, whereas the monosyllable *et* occurs in 97 clausulae, not one of which is irregular. While this comparison is not as impressive as it would be if we took the entire text of Ammianus into consideration, it nevertheless shows clearly that the relative is not handled like other monosyllables. Hence we must infer that it is not on all occasions monosyllabic.

Again, in the three words *quies*, *quibus*, *quidem* we have asserted not only that the *u* counts as a syllable but that it bears the accent. This remarkable phenomenon is far harder to admit than any other application of the principle of syllabic *u*. Yet it must be admitted, for in every single clausula in which the word *quies* appears it is treated as if it were an antepenultimate trisyllable like *requies* instead of a dissyllable.¹ Since this fact cannot possibly be due to the blind working of chance, the only admissible explanation is the obvious one that to the ear of Ammianus the word had the effect of an antepenultimate trisyllable—an effect which can have been secured only by pronouncing it *quies*. Thus the evidence for *quies* is just as strong as the evidence for, let us say, *sibinde*. And from *quies* we get the key to the explanation of the apparently irregular cadences in which *quibus* and *quidem* appear.² It is very clear, then, that in Ammianus the syllabication of *u* after *q* must be admitted.

In trying to account for a feature of his pronunciation so contrary to good usage as exemplified in the poets, one is naturally tempted to see in it an idiosyncrasy due to his Greek birth, inasmuch as transliterations like *Κόϊτρος* indicate that to the Greeks the Latin *u* seemed syllabic.³ This consideration should not be ignored, yet we must not overrate its importance. In the first place it should be

¹ Except in *patitur quies* (II. 67. 32), where either trisyllabic or dissyllabic pronunciation of *quies* would give a regular form.

² That *quibus* should occur in 3 apparently irregular clausulae is in itself suspicious, in view of the fact that it is rarely to be found in a regular cadence.

³ This is shown not only by the fact that the *u* is represented by a vowel, but even more conclusively by the accent which falls upon the vowel.

kept in mind not only that the Histories were intended to appeal to a more or less cultivated public, but that they were actually read in sections before an audience and were received, if we are to believe Libanius, with great applause. Consequently we should be chary of assuming the existence of any conspicuous idiosyncracies or Hellenisms in the pronunciation of Ammianus; they would not have escaped attention and censure at the first reading.¹ Furthermore, there is some little outside evidence to show that this phenomenon was not entirely foreign to the Latin ear.

Lachmann long ago pointed out that in the early poets the word *aqua* is in several instances trisyllabic (*aq̄ua*).² This is certainly the case in Lucretius VI. 552 and 1072, and again in VI. 868 if we follow Lachmann in substituting *aq̄uae* for *laticis* on the authority of an unknown grammarian.³ The same scansion is found in Ennius in one place (*Ann.* 168 *Vahlen*), and perhaps in another (*Ann.* 379).⁴ Lachmann, seconded by Bergk, maintained its occurrence in the drama also; this Ritschl stoutly denied,⁵ and the Plautine scholars have acquiesced in his view. However it may be with this matter, which in the absence of any new evidence it would be out of place to discuss, it is certain that *u* after *q* in Plautus was not entirely without effect upon the metre, for Lindsay notes that words like *loqui* resist 'iambic' shortening of the ultima. He explains this by saying⁶—"so to the ear of Plautus *qu* almost made a preceding vowel long by position, unless we say that *loqui* etc. sounded to Plautus something like a trisyllable." Surely, *ceteris paribus*, the latter of his alternatives is preferable.

After the time of Lucretius this license apparently is avoided by

¹ Of course this argument does not apply with the same force to an inconspicuous feature like the syllabication of intervocalic *i*, which we have hesitatingly ascribed to Ammianus' Greek origin, and which affects so few clausulae that it may well have passed unnoticed.

² See his note on Lucretius VI. 552.

³ In the latter passage Lachmann's reading, vigorously defended by Bergk and as vigorously opposed by Ritschl, has been adopted by Bockemüller and by Munro. Giussani retains *laticis*.

⁴ Cf. Bergk, *Opusc.* I. 309, 345. In *Ann.* 379 he would read *erugit* for *exerugit*. In *Ann.* 155 *Vahlen* rejects *Tarcūini corpus* (Servius) in favor of *exin Tarquiniūm* (Donatus).

⁵ Lachmann *ad Lucr.* VI. 552; Bergk, *Opusc.* I. 72; 345; Ritschl, *Opusc.* II. 600, 604; Schroeder, *Studemund's Studien* II. 20.

⁶ *Lat. Lang.* p. 87. The italics are mine. The fact that such words are occasionally shortened does not invalidate the general truth of his remark.

the poets, even by those of Ammianus' own age.¹ Nor have I been able to find any certain indication of its occurrence in the rhythmical prose of Sedulius, Cassiodorus or Ennodius.² In the grammarians, however, there are some traces of the phenomenon. Velius Longus says,³ *aquam quoque per q scribentes nomen ostendimus, per c vero verbum ab eo quod est acuo, utinam acuam*. Now if men had to be told to write *aquam* when they meant water and *acuam* when they meant sharpen, we can fairly infer that they made little if any distinction between *qu* and *cu* in pronunciation. The remark of another grammarian,⁴ *vacua non vaqua, vacui non vaqui*, points in the same direction. And there is still more significance in the statement of Consentius,⁵ *u quoque litteram aliqui pinguius eferunt, ut cum dicunt ueni putes trisyllabum incipere*. To be sure it is the syllabication of initial *u* to which his words primarily bear witness, but it stands to reason that any person who made *ueni* a trisyllable would have treated *Quadi*, for example, in the same way. In fact, *qu* appears to have been much more subject to syllabication than initial *u*, inasmuch as Ammianus, who makes so free with *qu*, does not allow initial *u* to count as a syllable.

There is then some evidence for the existence of a considerable tendency in Latin toward the syllabication of *qu*. For aught I see to the contrary, the tendency may have been especially strong in late Latin. Even if a pronunciation as broad as that of Ammianus were general in his time, we could not expect to find adequate recognition of the fact either in the poets, who would follow tradition, or in the grammarians, whose concern was always with the written rather than with the spoken language. This consideration undeniably lends much weight to the scanty evidence that we actually find, which, although it is far from strong enough to be decisive, is yet sufficient to make us hesitate to ascribe the broadness of Ammianus' pronunciation to Greek influence.

Another fact still remains to be recorded in regard to Ammianus'

¹ Yet the syllabication of *u* in *cūi* (e. g. Martial I. 104, 22) is parallel.

² Subsequent investigation may reveal it in the usage of other writers—may perhaps reveal also that some writers who do not allow *qu* to count as a syllable have a tendency to avoid using words containing *qu* in the clausula, which would be hardly less significant than positive testimony in support of our point.

³ K. VII. 75, 10.

⁴ Probi App. K. IV. 197. 23.

⁵ K. V. 395. 15.

treatment of *u*—namely, that syllabication occurs also after *r* in the words *seruo* and *obseruo* (I. 254. 8; 263. 11; II. 117. 3; 269. 23; 273. 23), and possibly in *paruus* (II. 269. 5; 33. 17). Herein, of course he again contravenes poetical usage, in which the only approximation to a parallel is the ante-classical *larua*, *laruatus*, and *larualis* (Priap. 32. 13).

Neither initial nor intervocalic *u* appear to be subject to syllabication in his pronunciation.¹

QUANTITY.

For the sake of completeness mention should here be made of the fact already established that Ammianus was to all intents indifferent to vowel-quantity but not to syllabic quantity produced by position, which within certain limits is observed in his clausulae.² It has also been demonstrated previously that in his observance of positional quantity syllables ending in *-ns* and *-nt* are not considered long.³

FORMS.

In regard to the form of the genitive singular of nouns with *-io-* stems the clausula reveals nothing new in the usage of Ammianus and simply confirms the testimony of the manuscript to the effect that in proper names both the old form in *-i* and the newer form in *-ii* are used indifferently, while in common nouns only the newer form is employed.⁴

In proper names the old form in *-i* is demanded by the clausula (sometimes against the manuscript) in

Constanti	I. 67. 6; 25. 26; 38. 15; 284. 13
Antoni	I. 319. 8
Eusebi	I. 153. 22
Theodosi	II. 185. 26
Vadomari	I. 233. 27
Danubi	I. 139. 1

The new form is demanded, either with or without manuscript sanction, in

¹ There are so many instances in which he does not resort to it that we can hardly employ it to explain the two clausulae *Massa Veternensi* (I. 42. 30) and *saevum reptorem* (II. 193. 8).

² p. 187 ff.

³ p. 192 and note 3.

⁴ Neue, *Formenl.* I. 154.

Constantii	I. 46. 1; 150. 21; 251. 26
Craugasii	I. 168. 19; 208. 18
Chnodomarii	I. 102. 32
Aesculapii	I. 296. 9
Procopii	II. 89. 17
Strategii	II. 75. 16
Vulcatii	I. 253. 4

The only case, as far as I know, of a common noun with the genitive in *-i* is *triclini* (I. 48. 17), which is called for by the manuscript as well as by the clausula, and which is to be accounted for by the fact that the title *triclini rationalis* had become formulaic through long use. Instances of the ordinary genitive in *-ii* may be found in the following passages: I. 96. 11; 103. 15; 113. 4; 175. 25; 193. 11; 279. 17; 284. 13; 317. 16; II. 4. 9.

Other points that I have noted in this connection are but few. The laws of the clausula support the manuscript reading *communibat* in I. 163. 7 and require the introduction of the same form in II. 138. 1, and *custodibat* in II. 84. 30. They reject *praesagiebat* in I. 310. 34 (where V has *praesagebat*), and require either *praesagibat* or *praesagabat*. Again, in II. 78. 15 they condemn the traditional *detestabant* and favor the substitution of the usual form *detestabantur* (cf. I. 291. 15).

CHAPTER IV. CRITICISM.

The observation that Ammianus favored certain cadences in his clausulae and avoided others is of course one of great importance for text-criticism. Its practical significance is but little limited by our uncertainty as to the exact status of the avoided cadences, for even if they were not rejected altogether they were certainly so seldom used that any reading which presents one of them is thereby rendered suspicious and subject to emendation if emendation is possible.

The principal matter of critical interest that has come to my attention in working through the Histories is that in those cases in which lacunae are filled out by Gelenius his suppleta conform to the requirements of the clausula.¹ We must therefore consider them

¹ E. g. I. 265. 17; 288. 18-20; II. 24. 5; 25. 28-29; 26. 3; 83. 2. This fact has already been pointed out by Clark (*Text Tradition of Am.* p. 65), who also refers to Mommsen's vindication (*Hermes* 15. 244) of one of these suppleta (II. 98. 14) on an epigraphic basis.

genuine and attribute them to the lost Marburg manuscript; for that Gelenius himself did not appreciate the nature of Ammianus' clausulae is shown by many instances in which his attempts to better the text have resulted in the introduction of irregular cadences. For example, the words which he omits in II. 140. 21; 142. 28; 143. 20; 145. 11, and which Gardthausen brackets in deference to him, are necessary to fill out the clausula in each case.

Here and there in the text of the Histories interpolations have been observed and bracketed by the editors. Sure cases are to be found, for instance, in I. 77. 18 (Julian) *ita . . . conluxit ut prudentia* [Vespasiani filius] *Titus alter aestimaretur*, in I. 81. 18 *tamquam adstrictus sumptuariis legibus viveret—quas ex rhetris Lycurgi* [id est axibus] *Romam translatas*, etc., and in II. 210. 5 *Callistratus quem nobilem illam super Oropo causam* [qui locus in Euboea est] *perorantem*, etc. With such precedent I feel no reluctance in holding that interpolations occur in a number of other places where the clausula shows that the text is suspicious. In I. 70. 1 (*vias rex Cottius*) *in amicitiam Octaviani receptus* [principis] *molibus magnis extruxit* the removal of the superfluous word *principis* is advantageous to the rhythm. Similarly *Rhenum* is superfluous in I. 96. 17 *alii occupatis insulis sparsis crebro per flumen* [Rhenum] *ululantes lugubre*, etc. In I. 73. 22 (*Rhodanus*) *paludi sese ingurgitat* [nomine Lemanno] *eamque intermeans*, etc., the words *nomine Lemanno* are not superfluous, to be sure, but they break the rhythm. In the amusing description of Constantius (I. 92. 17 ff.)—*nam et corpus perhumile curvabat portas ingrediens celsas, et velut collo munito rectam aciem luminum tendens nec dextra vultum nec laeva flectebat* [tamquam figmentum hominis] *non cum rota concuteret nutans, nec spuens aut os aut nasum tergens vel fricans mammeve agilans visus est unquam*—that *tamquam figmentum hominis* is an interpolation is indicated not only by the rhythm but also by the fact that Ammianus has previously introduced a simile in the phrase *velut collo munito*. Two instances in Book XXI have already engaged our attention—I. 250. 14 *et quidam elatis super capita scutis* [ut pugnaturi levius] *alii vehentes umeris ut antea scalas ferventique impetu procurrentes pectora multiformium telorum ictibus exponebant*, where the bracketed words can have been added only by a person who did not understand the meaning of *elatis super capita scutis*, and 258. 9–10 *monstrare quibus primordiis hi genii animis conexi mortalium eas tamquam gremiis suis susceptas tuentur* [quoad licitum est] *doctique maiora si senserint puras et a conluvione peccandi immaculata corporis societate discretas*, where the restriction *quoad licitum*

est may, I think, be safely assigned to Christian influence. In II. 25. 25 *quod et civitas situ ipso* [inexpugnabilis] *defendebatur, et cum metuenda multitudine protinus rex adfore credebatur*, the word *inexpugnabilis* is more easy to account for as a marginal note than as an original element of the sentence. In II. 185. 4 *interque gemitus mortis et vulnerum audiebantur barbarorum ululabiles fletus* [captorum et caesorum] the sense as well as the rhythm of the passage condemns *caesorum*; and finally, in II. 193. 22 (*Iesalenses*) *per tramites adortus obliquos* [unde parum sperari potuit] *ad penuriam vastavit extremam*, the words bracketed may well have been added to explain *tramites obliquos*.

To examine in detail every passage in which the clausula discloses a fault in the accepted text and to essay the correction of them is the task of an editor—a task, be it said, to which Clark is doing full justice in the preparation of his new edition of Ammianus.¹ I shall simply submit here by way of illustration a few corrections which seem to me to be fairly certain.²

- I. 27. 29 (Isauria) uberi palmite viget et frugibus minutis. *The ms. reading multis should be kept.*
33. 3 caeli reserato tepore *Read* reserata temperie; *cf.* 240. 27.
82. 21 poeticam mediocriter et rhetoricam (amavit) *The addition is Wagner's: it would better be changed to amans.*
112. 9 duci praecipit *Read* praecepit.
204. 10 in stativa solita cesserunt *Read* recesserunt *with Gelenius; in* 293. 25 accensisque cereis ex usu cessit *read* recessit (usuccessit V).
204. 14 omnes petiverant palatium V petiverat; *read* petivere.
210. 1 cum auxilio equitum ilico ob repentinum malum inclusorum malum *is a conjecture on the part of Castellus; V reads* ad, *which points toward* aditum.
219. 24 in locum Florentii praefectum praetorio Nebridium tum quaestorem eiusdem Caesaris promovet *Read* promovebat.
228. 15 interiores (undae) sine ulla concretionem caeruleae *Read* caeruleae.
228. 19 apud poetas legimus saepe Irim de caelo mitti *Read* huc mitti *with Accursius: V has* hinc, *which is omitted altogether by Gelenius.*

¹ In process of publication by Weidmann.

² Other passages are handled in the commentary to Book XXI, and in the following places; p. 167, n. 1; 169, n. 2; 171–175; 176, n. 2; 184, n. 2; 185–186; 208, n. 1; 209, n. 2; 226, n. 2; 233–234; 241, n. 1.

290. 27 (plebs omnis) Georgium petit raptumque diversis mulcandi generibus proterens et conculcans divaricatis pedibus *Günther (Quaest. Amm. Crit. p. 36) pointed out that a verb is wanting at the end of the sentence and suggested divaricatis (conficit) pedibus, which fills out the clausula.*
294. 17 Galli similis fratris licet incruentus *Insert hic, comparing II. 258. 26 semet ad vana studia Caesaris Commodi convertisset licet hic incruentus.*
- 27 quorum proceritatem Homerus in immensum tollit *Read extollit.*
- 31 stipatusque mulierculis litabat litabat *is Gardthausen's conjecture for the ms. laetabatur, which should be retained. See Schneider p. 20.*
302. 19 Pentapolim a Libya sicciore disparatam V dissoratam, *Gelenius disparatam; read discretam.*
306. 14 *The clausula confirms Valesius' emendation of non to Platon, thus disposing of Gutschmid's suggestion Jesus.*
308. 24 interitum propinquare monstrabatur *This is the reading of Accursius: V has monstrabant. Read monstrabat (Bentl.).*
- II. 31. 21 ita capitibus diligenter apta ut inbracteatis, etc. *Read aptata ut with Gelenius; V aptavit. Cf. I. 102. 24.*
47. 27 riparum aggeribus humana manu structis structis *is Haupt's conjecture: V distructis. We should probably read exstructis.*
53. 2 aliaque herbarum genera tristissima. *The manuscript reads genera ut tristissima, which Günther (Philol. 50. p. 72) properly corrects to vel.*
71. 29 *Read partiti (sunt) numeri.*
84. 19 *Read suorum (est) manibus.*
108. 18 nihil alienum putare quod ad Romani imperii pertinet salutem salutem *is Haupt's conjecture: V reads latus, which gives a good clausula. The figure of speech is not bolder than many in Ammianus.*
114. 11 ex eo anhelantes *The rhythm warrants C. F. W. Müller's reading ex eo (altius) anhelantes.*
129. 7 cuius hunc novimus esse textum. *This is the reading of Gelenius and Accursius; V has fuisse novimus textum which is commended not only by the clausula, but by the recurrence of a similar phrase in 200. 6 (cuius) hanc primordiale fuisse novimus causam.*

157. 25 Romanus quas ob res venerat ante praestructurus praestructurus *Gardthausen*; V praestructus, *which gives praestructis.*
161. 2 nec carceres publici iam distenti inclusorum iam catervas *The second iam should be deleted.*
183. 14 (cuius virtutes) prae ceteris nitabant *Read eminebant.*
219. 29 (death of Valentinianus) ne laberetur spectantibus et vilibus concursu ministrorum vitae secretioris ad conclave ductus est intimum *To better the rhythm, read spectandus et vilibus.*
256. 6 ut quidam laudes extollendo principis iactarunt *Read iactitarunt; compare I. 8. 28, 19. 6*
260. 27 (Sebastianus Gothorum vastatorios cuneos) opertus aggeribus et fructectis obscura nocte suspensis passibus inconpositos adgressus est *V's reading is conpositos, which should be corrected to consopitos.*
272. 17 per Christianum quendam portatis scriptis et recitatis utque decebat contemplatis contemplatis *Accursius; contemptatis V Read contemptis, which the sense demands (v. l. 11-12).*

In a number of passages apparent breaks in the rhythm are due not to the condition of the text but to the punctuation of it. A few cases of this sort may be cited here.¹

- I. 46. 22 ut quondam Domitius Corbulo dicitur caesus in conlutione illa Neroniani saeculi provinciarum fidus defensor et cautus *Gardthausen sets a comma after saeculi.*
96. 19-20 qui graviore motu animi percitus ad corripiendos aliquos septem a Barbatione petierat naves *G. sets a comma after aliquos.*
118. 13 utque (obeliscus) radium imitetur gracilescens paulatim specie quadrata in verticem productus angustum *G. punctuates after gracilescens.*
190. 24 stabant incurvi longe alia quam quae gestu praeferebant et verbis altis mentibus perpensantes. *G. sets a comma after altis.*
210. 28-211. 1 petitusque ballistarum ictibus certis et sagittarum, densitate opertus armorum, etc. *G. punctuates after densitate.*

¹ One instance (I. 88. 1) has been already discussed p. 167 n. 2. No note is here taken of mere typographical errors such as II. 139. 16 *barbaricus prosiluit, globus* and I. 234. 3 *manus, praedatorias*, nor of 'grammatical' punctuation where there is no pause (*is, qui*) and the like.

250. 6 datoque signo in receptum ex more ambo digressi *G. punctuates after receptum.*
309. 15-16 rumore praecurso hostiles occupare properans terras, nondum adulto vere missa per militares numeros expeditionali tessera etc. *G. punctuates after vere.*
323. 11 venit ad Carmaniae sinum orienti obiectum. Intervallo Cantichus nomine panditur sinus australis. *G. sets the period after intervallo: the error was corrected by Petschenig (Phil. 50. 351) and the rhythm confirms him.*
- II. 41. 15 (Juliani) Fortitudinem certaminum crebritas ususque bellorum ostendit et patientia frigorum immanium et fervoris. quamquam corporis munus a milite ab imperatore vero animi poscitur, ipse etc. *For quamquam (Kellerbauer) V. has quoque, which G. retains, setting a period after it.*
88. 10 eumque secuti complures iam pila quotientes et gladios ad imperatorem transeunt cum vexillis scuta perversa gestantes *G. sets comma after transeunt.*
112. 20 ff. exinde transmeato lentius freto tranquillam. Unde cum consecuti Batavi venissent et Heruli Ioviique et Victores fidentes viribus numeri egressus etc. *This is the traditional reading, in which unde of course is to be construed with egressus. G. writes tranquilla unda. Cum, etc.*
140. 4-6 At procul tamquam horum similia agitantibus furiis per omne latus Maratocupreni grassatores acerrimi vagabantur *G. sets a comma after latus.*
174. 11 qui cum abstinere inconsolabili malo rogaretur obnix, inflexibilis mansit *G. sets a comma after rogaretur.*
206. 22 quia rem Romanam alius circumsteterat metus totius Gothiae Thracias licentius perrumpentis. *G. sets a comma after Gothiae.*

Turning now from the field of text criticism to that of higher criticism, let us examine the conclusions which can be reached by the aid of the clausula. The facts may be summed up in the statement that except for a few direct quotations the whole text of the Histories conforms to the rules that we have laid down in regard to the practice of Ammianus. This proves first that the Histories contain no interpolations of any significance, and secondly that very little of the material upon which they were based was taken over by Ammianus verbatim. This latter point is one that

merits some emphasis. It is only natural, to be sure, that in a geographical excursus, for instance, he should recast the data which he obtained from published sources; but that he should rewrite all the letters and speeches which his work incorporates is a matter of more moment. A recent writer has ventured to assert that "Ammianus, unlike other Latin historians whom we have read, does not *make* speeches for his characters to deliver."¹ Yet both speeches and letters conform throughout to the manner of Ammianus and cannot be authentic except perhaps in their general tenor. An interesting letter may be instanced—the enigmatic warning of Procopius to Ursicinus, originally written in short-hand, which in Ammianus' version runs as follows (I. 160. 22 ff.)

Amendatis procul Graiorum legatis	I
forsitan et necandis	III
rex longaevus non contentus Hellesponto	II
iunctis Granici et Rhyndaci pontibus	II
Asiam cum numerosis populis pervasurus adveniet,	II
suapte ingenio	II
inritabilis et asperrimus,	IV
auctore et incensore	III
Hadriani quondam Romani principis successore :	III
actum et conclamatum est	IV
ni caverit Graecia.	II

We may be sure that this is not the way in which Procopius expressed himself. Other good examples are the letter of Sapor to Constantius (I. 122. 16 ff.) and the reply of the emperor (I. 223. 22 ff.). As for speeches, the reader will find in Book XXI the addresses of Julian and of Constantius to their respective forces, both in the style of Ammianus. A detailed analysis of the speeches of Constantius, Julian and Valentinian brings out the fact that all three agree with one another and with Ammianus not only in the cadences which they employ but (still more significantly) in the relative frequency of the various cadences. This is brought out in the following table, based on three speeches of Constantius (I. 64. 29 ff.; 143. 7 ff.; 255. 13 ff.), three of Julian (I. 99. 20 ff.; 236. 28 ff.; II. 37. 21 ff.), and two of Valentinian (II. 67. 4 ff.; 106. 28 ff.). The results are expressed in percentages, and compared with the normal ratios in Ammianus.²

¹ Glover, *Life and Letters in the Fourth Century*, p. 29.

² See p. 205.

Form	Ammian.	Constantius (211 clausulae)	Julian (154 clausulae)	Valentin (114 clausulae)
I	46	47	47	52
II	27	28	22	21
III	24	23	27	22
IV	3	2	4	4

So unequivocal is this evidence that I should as soon think of maintaining the authenticity of the speeches in Vergil as of those in Ammianus. In fact, with the exception of occasional citations from books almost everything in the Histories that purports to be a direct quotation owes its present form to the pen of Ammianus. From the line of battle a standard-bearer calls out to Julian (I. 101. 21)

perge felicissime omnium Caesar
 quo te fortuna prosperior ducit:
 tandem per te virtutem et consilia militare sentimus
 i praevis ut faustus antesignanus et fortis:
 experieris quid miles sub conspectu bellicosi ductoris
 testisque individui gerendorum
 (modo adsit superum numen)
 viribus efficiet excitatis.

Sulla in the excitement of battle shouts to his wavering men (I. 106. 5)

ite socii periculorum electi
 et scitantibus ubi relictus sim imperator
 respondete nihil fallentes:
 solus in Boeotia pro omnibus nobis
 cum spendio sanguinis sui decernens.

When a bailiff violated good form by holding out both hands to receive a present from the emperor instead of allowing it to be dropped into the folds of his garments, Julian remarked 'rapere non accipere sciunt agentes in rebus'; and again, when he was reproached with leniency, he said

incusent iura clementiam,
 sed imperatorem mitissimi animi
 legibus praestare (ut) ceteris decet.¹

When a gentleman named Nigrinus was asked for a position, he replied laughingly

¹ I. 83. I retain the ms. reading *ceteris* in the last clause, and insert *ut*. Gardthausen follows Kellerbauer's conjecture *severis*.

fac me imperatorem
si id volueris impetrare.

Occasionally Ammianus seems to retain the actual words of a short quotation, but fills out his clausulae with a *verbum dicendi*. An example is the exclamation of the actor in Antioch, when the Persians surprised the people in the theatre: "nisi somnus est" inquit "en Persae!" The remark of Iphicles when the emperor asked him if the people of Epirus spoke from their hearts in praising their prefect, may also be cited: "Gementes" inquit "et inviti." I can refer to but two quotations of this sort which have irregular clausulae: when Gratian was elevated to the purple, Eupraxius exclaimed *familia Gratiani hoc meretur*, and when Valentinianus had ordered a wholesale execution of dignitaries in several cities, Florentius remarked

ecquid agetur si oppidum aliquod
curiales non haberet tantos?
inter reliqua id quoque suspendi debet
ut cum habuerit occidantur.

Even in Ammianus' citations from books a few trifling changes in the direction of a better rhythm are discernible, but it may well be that these are unintentional.¹

¹ Thus I. 9. 2 (order); 232. 23 (*erraverit* for *erraverunt*); II. 149. 26 (transposition of *se*). It should be noted that many of Ammianus' quotations cannot be tested, as the works from which they were taken have perished.

FORM I.

	β	γ	δ	$\gamma\delta$	$\beta\gamma$	Total
1 x (— : x)		290	107	52	2	451
2 — (— —	10	162		24		196
3 (— — —		15	60	1		76
4 — (— —		10	1			11
5 (— — —	2	18		3		23
6 — — — (	8	11				19
7 (— — —	4	1				7
8 (— — —						
9 x (— — : (x)		[1] ¹	34	22		57
10 — — — —		[1]		8		9
11 (— — —			20	2		22
12 — — — (			1			1
13 (— — —						
14 — — — (
15 (— — —						
16 (— — —						
	24	509	223	112	2	870 ²

FORM II.

	γ	δ	$\gamma\delta$	$\gamma\zeta$	Varia	Total
1 x (— — x)	33	7	16	13	1	70
2 — — — —	9		12	5		26
3 (— — —	2	6	1	1		10
4 — — — (	2	5		1		8
5 (— — —				1		1
6 — — — (	2					2
7 (— — —	2					2
8 (— — —		1				1
9 x (— — : (x)	35	5	13			53
10 — — — —	8		2			10
11 (— — —	2	1	1			4
12 — — — (	1					1
13 (— — —						
14 — — — (	2				1	3
15 (— — —	1					1
16 (— — —		2				2
17 x (— — : x)				4		4
18 — — — —				1		1
19 — — — (					1	1
20 x (— — : (x)		[1]				1
21 — — — —			[1]			1
	99	28	46	26	3	202

¹ The brackets mark an instance ordinarily impossible to the type, but occurring in virtue of exceptional accentuation.

² I do not count the three cases registered as possible one-word clausulae.

FORM III.

	γ	δ	$\gamma\delta$	$\delta\epsilon$	Varia	Total
1 \bar{x} () : - (\bar{x})	8	62	5	3	1	79
2 - - - -	4	[1]	8		1	14
3 () ()		34	1	3		38
4 - () ()	1	53	3	2		59
5 () - -	1		2			3
6 - - - ()	1		1			2
7 () - - ()						
8 () () ()		26		3		29
9 \bar{x} () - : - - - \bar{x})	7	91	10	9		117
10 - - - -	5		6		1	12
11 () () -		55		2		57
12 - () ()		76	1	3	1	81
13 () - - -	2					2
14 - - - ()	1			[1]	1	3
15 () - - ()		[1]				1
16 () () ()		34		3		37
17 \bar{x} () - : () - \bar{x})	8	33	3	2		46
18 - - - -	3	[1]	1		1	6
19 () () - -		20		2		22
20 - () ()	4	10	1	1	1	17
21 () - - -	1	[1]	1			3
22 - - - ()	3					3
23 () - - ()						
24 () () ()		6				6
25 \bar{x} () - : () () \bar{x})	3	9				12
26 - - - -	1					1
27 () () - -		11				11
28 - () ()	2	10		1		13
29 () () ()		6				6
30 \bar{x} () - : - () \bar{x} - ¹				1		1
	55	540	43	36	7	681

¹ *eúagis et drasidas* (I. 69. 11): various instances in which the last accent of this clausula falls on a short syllable may be found in the lists given on p. 214.

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Nutrition Investigations
on the
Carbohydrates
of
Lichens, Algae, and Related
Substances

BY

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This paper has been prepared from the author's dissertation submitted for the degree of doctor of philosophy, Yale University, 1909.

I. INTRODUCTION.

LICHENS, ALGAE, TREE BARK AND CERTAIN TUBERS AS FOODSTUFFS.

From the earliest times, the food of man has included lichens and algae, and even the tender branches and inner bark of certain trees and shrubs, such as elm, birch, pine, and the staff-tree or bitter-sweet (*Celastrus scandens*). When the bark of trees is so used, it is freed from cork and the hard outer rind; is cleaned, dried, mixed with more or less meal, and made into "bark bread." Such substitutes for bread are commonly resorted to only in northern lands where there is scarcity of cereal crops, or in other regions during periods of famine. Johnson (7) records that elm bark is so employed in some continental countries, and Dillingham (4) relates that certain tribes of North American Indians, 'in times of extreme dearth, were accustomed to keep body and soul together by boiling and eating the bark of the staff-tree.' Poulsson (17) states that in Finland and northern Russia, sphagnum mosses are similarly employed; and Schneider (21) agrees with these other writers, saying that in general lichens are used as articles of diet only in cases of special need, principally because all lichens contain a bitter principle, which not only gives an unpleasant flavor and is difficult to remove, but also exerts an irritating effect upon the digestive tract, causing inflammation. Nevertheless, in the northern parts of the Scandinavian Peninsula, where cereal crops are always scanty or uncertain, great interest attaches to two species of lichen widely distributed through Europe, and through Arctic and Antarctic regions: namely, *Cetraria islandica* and *Cetraria nivalis*, which, as Poulsson (17) observes, 'have been considered nutritive and easily digestible since olden times.' *Cetraria islandica*, whitened and freed from its bitter principle by washing with dilute alkali, is a rather appetizing substance; it has sometimes been used as a foodstuff by Polar navigators, and Dr. Hansteen, chief lecturer in the Agricultural school at Aas, Norway, has gone so far as to prophesy that moss is destined to become the great popular food for the masses, because of its cheapness and nutritive properties.

Of marine algae, many tons are gathered and eaten annually in various parts of the world, the largest quantities being consumed

by the Japanese, Chinese, and Hawaiians. These algae are found in great variety and widely distributed. In Japan, the general name applied to them is "Nori," which is also given to several prepared products. According to H. M. Smith (23), the most important Japanese seaweed preparations are: "Kanten," or seaweed isinglass, made from various species of *Gelidium*, the principal one being *Gelidium corneum*, often adulterated with similar seaweeds; "Kombu" made from Kelps, especially numerous species of *Laminaria*, *Arthrothamnus*, and *Alaria*; "Amanori," from species of *Porphyra*; and "Wakame," from *Undaria pinnatifida*.

Kanten is used largely for food, in the form of jellies, and as an adjunct of soups and sauces. According to H. M. Smith (23), it is also employed in foreign countries 'in jellies, candies, pastries, and many desserts, in all of which it is superior to animal isinglass.' It has recently also attained popularity as a therapeutic agent in chronic constipation, being sold under various trade names, either plain or impregnated with laxative drugs, as cascara or phenolphthalein.¹ Kombu enters into the dietary of every Japanese family, being cooked with meat, soups, etc., and also served as a vegetable, or made into a relish with Soy-bean sauce. Amanori is eaten fresh or else is chopped and sun-dried in thin sheets, which are toasted over a fire before eating. The crisp amanori is crushed between the hands and dropped into sauces or soups to impart flavor; or broken into pieces, dipped in sauce and eaten alone. Sheets of amanori, spread with boiled rice and covered with strips of meat or fish, are rolled and cut into transverse slices, and take the place of the American sandwich. Wakame is eaten as a salad, or cooked like amanori.

In Hawaii, edible algae are called "limu." Of these there are over seventy distinct species used for food, more than forty being in general use (18). Tons of limu are gathered for eating in Hawaii annually, and large quantities are also imported from the Orient and San Francisco. Some idea of the extent of their use may be gained from the following statement by Miss Reed (18): "Ancient Hawaiians probably seldom ate a meal without some kind of limu, and even today no Hawaiian feast is considered quite complete without several varieties served as a relish with meats or poi."² Since, with the exception of a few experiments reported by Oshima (15) and Saiki (20), there are no

¹Cf. Galactans, p. 283.

²Poi is a thick paste made from the root of the taro plant, and takes the place of rice or bread in the native diet.

data upon the digestibility of marine algae, an investigation of some of these Hawaiian limu seemed highly desirable; and through the kindness of Miss Reed, a number have been obtained for this purpose. Their occurrence and uses will therefore be described in some detail.¹

These limu are washed carefully after gathering, salted, and usually broken, pounded, or chopped into small pieces. They may then be eaten uncooked, as a relish with poi, meats or fish; boiled with meats; put into soups for thickening or flavoring; or roasted with pig in a pit. Served raw and crisp, they take much the same place in the diet as our salads. Among the most popular varieties are *Limu Eleele* (*Enteromorpha* of various species), *Limu Kohu* (*Asparagopsis sanfordiana*) and *Limu Lipoa* (*Haliseris pardalis*). Next in favor come *Limu Manauea* (*Gracilaria coronopifolia*), *Limu Huna* (*Hypnea nidifica*) and *Limu Akiaki* (*Ahnfeldtia concinna*). *Limu Pahapaha* (*Ulva fasciata* and *Ulva lactuca*) is widely distributed but not very popular. *Limu Uaualoli* (*Gymnogongrus vermicularis americana* and *Gymnogongrus disciplinalis*) is limited to certain islands, and hence not in such general use and favor as some of the others.

Limu eleele is a great favorite, forming a part of every native feast. It is generally eaten uncooked, sometimes being dropped into hot gravy, broth or meat stews just before serving. Limu kohu is always pounded in cleaning to free it from bits of coral and soaked 24 hours in fresh water to remove the bitter iodine flavor. It becomes slightly fermented and acquires a somewhat sour taste. Limu lipoa is popular on account of its penetrating spicy flavor, and is frequently used as a condiment, taking the place of sage and pepper in Hawaiian foods. Limu huna is especially prized for boiling with squid or octopus, though limu manauea and limu akiaki are often used as substitutes. These limus, as well as limu kohu, yield large amounts of mucilaginous extract on boiling, limu manauea being considered especially fine for thickening chicken broth.

Many of the seaweeds used in Hawaii and Japan occur also along the coasts of the United States and Europe, and are to some extent used as food in both regions. The very species of *Gelidium* from which the Japanese prepare their Kanten grow in abundance on our Pacific coast. Irish moss (*Chondrus crispus*), the "Tsunomata" of Japan, has long had considerable commercial value as a foodstuff in Ireland. In this country it is found from North Carolina to Maine, being especially abundant north of Cape Cod. After cleansing, cur-

¹For fuller description see Reed (18).

ing, and bleaching it is to some extent used for making blanc mange or a demulcent for coughs. Through the kindness of Dr. C. F. Langworthy, Nutrition Expert, United States Department of Agriculture, I have obtained the following interesting data concerning the use of Irish moss, from the Journal of the South-Eastern Agricultural College, Wye, Kent (1): "Professor D. Houston, of the Royal College of Science, Dublin, has favored us with the following notes on this subject:

Chondrus crispus (carrageen, or Irish moss) is a seaweed plentifully distributed along our northern, western and southern coasts. It is gathered and sold to local chemists, who retail it, in some parts at all events, at 6d. per pound. It is used by many people as an article of food in the west, and generally for colds, for which purpose it is boiled in milk.

Several of my students tell me that it is used for feeding weak calves and with striking results, bringing about an alteration of condition within four days. One student tells me that in one case at his own farm a batch of twelve calves took a kind of wasting disease, and nine died; the other three on the verge of death were given this plant, and all three recovered. It is prepared by putting one pound of the "weed" in a net bag and boiling in a gallon of water. The water on cooling sets to a jelly. The calves are given one glass of jelly in their milk each meal and wonderful results are said to be obtained."

The high proportion of mineral matter is noteworthy;¹ but without making a fuller investigation, it is impossible to say precisely wherein lies the value of this seaweed.

Purple laver (*Porphyra laciniata*), a source of Japanese amanori, is found in abundance on the rocky shores of America and Europe generally; but it is not used in this country save sparingly by the Chinese, who usually import it directly from China, and by some of the Indians of our northwest coast. In Ireland it is known as 'sloak,' and is boiled and served with butter, pepper, and vinegar as an accompaniment of cold meats, or is served with leeks and onions.

Dulse (*Rhodymenia palmata*) is found abundantly on rocky shores both in this country and in Ireland. It is very abundant in New England, where it is rough-dried in the sun and eaten as a relish. In Philadelphia it is called sea-kale and eaten as a vegetable. In Scotland it has long been used both in the fresh state and dried. In the Scotch Highlands, "a dish of dulse boiled in milk is," it is said, "the best of all vegetables." In Ireland, it is eaten with fish or boiled in milk with rye flour. Purple dulse (*Iridea edulis*), which occurs on the Pacific coast, is often eaten like *Rhodymenia palmata*.

¹Cf. Analysis of *Chondrus crispus*, p. 254.

Besides such lichens and algae, and the bark of trees, various tubers are used as food for man. In Japan, the tubers of *Hydrosme rivieri* (*Conophallus Konjaku*) are extracted with lime water, and the resulting gelatinous mass is cut into small cakes. These, cooked with "shoyu" or Soy-bean sauce form a common article of diet. The tubers of many species of *Orchis* and *Eulophia*, native to Turkey, the Caucasus, Asia Minor and the greater part of Central and Southern Europe, furnish a food material known as *Salep*. The small ovoid, oblong or palmate tubers are decorticated, washed, heated till horny and semi-transparent, and finally dried. An abundant mucilaginous extract is obtained by macerating the bulbs in water. Frequently the tubers are ground to powder, and the powder used like sago or tapioca. Royal salep, said to be used as food in Afghanistan, is prepared from *Allium Macleanii*. A former instructor in the American College for Girls, in Constantinople, reports that salep is a very common article of diet in Turkey. It is sold in the markets in powdered form, and is made into a sort of sweetened gruel with milk. Not only is it used as a warm drink in the household, much as we use cocoa or chocolate, but it is also sold in the streets by venders, who either stand in booths along the way, or go about carrying huge brass urns strapped to their shoulders, clinking their cups and calling "Tazé-Sahlep!"¹ It is especially popular in districts of the city where people work late at night. In the month of Ramazon, the time of all-day fasting, hot salep finds a ready sale at night. It is no uncommon thing to see the workman standing with his salep cup in hand, waiting for the firing of the sunset cannon.

In spite of the fact that there have been almost no scientific investigations as to the digestibility of such mucilaginous plant substances there seems to be a special virtue attached to mucilages in the popular mind. The prevailing impression is shown in some of the following remarkable statements. The United States Dispensatory, 1908, not only says that the mucilaginous extract of slippery elm bark (*Ulmus fulva, Michaux*) is nutritious, but adds, "We are told that it has proved sufficient for the support of life in the absence of other food." Of salep Smith (25) says in his dictionary of economic plants: "It contains a chemical substance called bassorin, which is said to contain more nutritious matter than any other vegetable product, *one ounce per diem* being sufficient to sustain a man"¹ The United States Dispensatory also assures us that salep is "highly nutritious." Johnson

¹Fresh salep.

(7) particularly recommends Iceland moss (*Cetraria islandica*) as a diet for consumptives, as "it seems to be both extremely nutritious and very easy of digestion, though of course, only capable of use as a substitute for starchy matters." In regard to Irish moss (*Chondrus crispus*), he is a little more uncertain. "It is much used for invalids, especially in cases of consumption, but with doubtful advantage when substituted for more nutritious food." Schneider (21) says of Iceland moss: "Inhabitants of Iceland, Norway, and Sweden mixed this lichen with various cereals and mashed potatoes, from which an *uncommonly healthful* bread was prepared." Until the matter has been thoroughly investigated, we must suspend our judgment as to the accuracy of such statements. After a few metabolism experiments, Oshima (15) far more conservatively remarks concerning the algae of Japan: "Their actual value doubtless depends in considerable measure upon the mineral salts they contain."

In view of the scarcity of any scientific investigations as to the behavior of all these substances in the body, further experiments upon their nature and digestibility seem highly desirable, since they are not only widely distributed, and already form a considerable portion of the diet of many persons: but because, if they possess any real nutritive value, a wider use of such comparatively cheap materials would be an economic advantage; and because, under the prevailing notions as to their food value, they are sometimes relied upon as a source of nutriment in diseases (as diabetes) where the character of the diet is particularly important. The present work has been undertaken to throw some light on this interesting subject. A survey of the literature shows that even the chemical nature of many of these algae has scarcely been investigated; and if this were known, we should still be under the necessity of studying their behavior in the animal body, for it is impossible to tell from chemical analysis alone whether a given substance will or will not prove digestible, as Rubner has long since warned us.

II. HISTORICAL PART.

INTRODUCTION.

According to the current practice of agricultural analysts, the carbohydrates of plants are reported as crude fiber and nitrogen-free extract. Crude fiber is the term applied to the resistant mixture forming the mature cell wall, shown as long ago as 1864 by Henneberg and Stohman (41) to have no definite chemical composition. It is therefore not identical with cellulose, but consists of a mixture of cellulose with incrusting substances, lignin and cutin, the relative proportions of which have recently been exhaustively studied by König (51), Fürstenberg (39), and Murdfield (63). Cellulose is the chief constituent; the other two are usually present in varying proportions.

Schulze (74) to whom much of our knowledge of the composition of the plant cell wall is due, has classified the carbohydrates of the nitrogen-free extract as follows:

- I. Water-soluble carbohydrates. To this class belong the mono-, di-, and tri-saccharides, and some soluble polysaccharides.
- II. Carbohydrates insoluble in water, but yielding sugar under the action of diastase. The chief member of this group is starch.
- III. Carbohydrates insoluble in water and resistant to the action of diastase, never being changed by it into sugar. This group is called the Hemicelluloses.

The term hemicellulose, as used by recent writers¹ seems to be interpreted to include some polysaccharides of the first group. It is therefore used here as a group name for those carbohydrates which are distinguished from cellulose by being capable of hydrolysis on boiling with dilute mineral acids, and from the other polysaccharide carbohydrates by not being readily digested by diastase. According to the kind of sugar yielded on hydrolysis, the hemicelluloses are designated as Pentosans or Hexosans, the latter including Galactans, Mannans, Dextrans, Levulans, etc. After a general review of the chemical

¹e.g., Lohrlich.

nature of lichens and algae, each of these classes will be discussed separately in detail.

The percentage composition of some common species of algae is shown in the following table:

FOOD MATERIAL.	WATER.	PROTEIN.	FAT.	CARBOHYDRATES.		ASH.
				Nitrogen-free Extract.	Crude	
I.* <i>Cystophyllum fusiforme</i> , dried.....	15.74	11.37	.49	54.84		17.56
<i>Ecklonia bicyclis</i> , dried.....	18.75	9.58	.46	51.63	9.79	9.79
<i>Enteromorpha linza</i> , dried (Limu eleele)....	13.53	19.35	1.73	46.18		19.21
<i>Laminaria</i> sp., dried....	23.08	7.11	.87	47.70		21.24
<i>Porphyra laciniata</i> , dried.....	13.98	33.75	1.30	41.22		9.75
<i>Ulopteryx pinnatifida</i> , dried.....	18.92	11.61	.31	37.81		31.35
II.† <i>Ahnfeldtia concinna</i> , fresh (Limu akiaki)....	80.00	1.4	0.0	14.4		4.2
<i>Ulva fasciata</i> and <i>U.</i> <i>lactuca</i> , fresh (Limu pahapaha).....	80.00	3.7	0.0	12.5		3.8
<i>Gracilaria coronopifolia</i> , fresh (Limu manauae)	80.00	1.8	0.0	14.1		4.1
III.‡ <i>Chondrus Crispus</i> , dried.	13.40	13.06	2.59	54.16	2.57	14.22||
IV.§ <i>Cetraria islandica</i>		0.32	1.2	43.3	5.3	2.2

* Oshima (15).

† Reed (18), (calculated on uniform water basis).

‡ Annet (1).

§ Schmidt (24), first studied the ash and reported a notable amount of calcium and potassium phosphates. He found no nitrogen. Blondeau (3) reported 21.36 per cent nitrogen.

|| Brown (334).

Until 1905 the chemical nature of the constituents of algae had received little attention. Analyses of many species of algae from Japan and China were reported recently by König and Bettels (8), the results of which are given in the following table on page 255.

According to Oshima and Tollens (16) the carbohydrates of *Porphyra laciniata* consist largely of anhydrides of *d*-mannose and *i*-galactose. Müther and Tollens (13) studying various species of *Fucus* (*F. vesiculosus*, *F. nodosus*, *F. serratus*), *Laminaria*, and *Chondrus crispus*, found a methyl-pentosan (*fucosan*), in *Fucus* and *Laminaria*; and glucose, fructose, galactose and pentose groups in *Chondrus*. Krefting reports a reserve carbohydrate in *Laminaria digitata* in win-

NO.	SPECIES OF ALGAE.	ANHYDRIDES OF HEXOSES.		ANHYDRIDES OF PENTOSES.	
		Galactose	Glucose	Fructose	Pentoses
1	<i>Porphyra</i>	Galactose	Glucose	Fructose	Pentoses
2	<i>Porphyra tenera</i>	Galactose	Glucose	Fructose	Pentoses
3	<i>Gelidium Raw</i>	Galactose		Fructose	Pentoses
4	<i>Gelidium Bleached</i>	<i>d</i> -Galactose		Fructose	Pentoses
5	<i>Celidium cartilagineum</i>	<i>d</i> -Galactose		Fructose	Pentoses
6	<i>Laminaria japonica</i>		Glucose	Fructose	Pentoses
7	Other <i>Laminaria</i>		Glucose	Fructose	Pentoses
8	<i>Cystophyllum</i>			Fructose	Pentoses
9	<i>Cystophyllum fusiforme</i>			Fructose	Pentoses
10	<i>Enteromorpha compressa</i>		Glucose	Fructose	Pentoses
11	<i>Ecklonia bicyclis</i>		Glucose	Fructose	Pentoses
12	<i>Undaria finnatifida</i>	<i>d</i> -Galactose	Glucose	Fructose	Pentoses

Methyl pentoses

Methyl pentoses

Methyl pentoses

Rhamnose

Methyl pentoses

ter only, which yields *d*-glucose. The algae investigated are thus all seen to yield pentoses, very frequently fructose and methyl-pentose, sometimes glucose and galactose.

Lichens are symbiotic forms embracing algae and fungi. Because of this symbiotic nature, they exhibit great variety in composition. From the investigations of Escombe (6), Ulander and Tollens (27), Karl Müller (11), Nilson (14), Wisselingh (29) and others,¹ it appears that the cell walls are usually of cellulose, but occasionally of chitin.² Many species yield on extraction with hot water a gelatinizing substance, which Berzelius (2) in 1808 named "Flechtenstärke" (*lichenin*), but which later investigators³ have shown to be, not a single substance, but a number of related carbohydrates yielding dextrose, such as *lichenin* from *Cetraria* and *Ramalina fraxinea*, and *evernin* from *Evernia prunastre*, *usnin* from *Usnea barbata*. Other species, on the contrary yield little dextran, but mannan, galactan, pentosan and methyl-pentosan in varying proportions. The table on page 257 showing the hemi-celluloses occurring in a number of lichens, has been compiled from data given by Karl Müller (11) and Ulander and Tollens (27).

OCCURRENCE AND NATURE OF CELLULOSE.

Cellulose is said to occur in pure form in the wall of the young plant cell. With increasing age, modifications take place by which the true cellulose becomes more and more encrusted with lignin and cutin, two substances shown by König (52), Fürstenberg (39), and Murdfield (63) to be almost entirely indigestible. According to Wielen (87) and Hofmeister (43), even pure cellulose is not a simple substance, but can be separated into soluble and insoluble portions.⁴ Much of our information regarding the nature of cellulose is due to the work of Schulze and his pupils. Schulze (75) has defined cellulose as that part of the cell wall giving the typical cellulose reactions,⁵ and yielding dextrose on hydrolysis with concentrated sulphuric acid.

¹For early literature see Czapek, *Biochemie der Pflanzen*, Vol. I, pp. 514-516.

²Chitin occurs in *Peltigera canina* and *Evernia prunastre*.

³Cf. Müller (11) and Ulander (26).

⁴According to its behavior in sodium hydroxide solutions, the quantitative relations depending upon the source of the cellulose and the concentration of the solution.

⁵Insolubility in dilute acids and alkalies; solubility in ammoniacal copper oxide solutions; and production of a blue color with iodine and sulphuric acid.

NO.	SPECIES OF CRYPTOGAM.	ANHYDRIDES OF HEXOSES.		ANHYDRIDES OF PENTOSES.	
1	<i>Cladophora glomerula</i>			Xylose	
2	<i>Cladonia rangiferina</i>	Glucose	Galactose	Pentoses	Methyl pentoses
3	<i>Cetraria islandica</i>	Glucose	Galactose	Pentoses	Methyl pentoses
4	<i>Evernia prunastre</i>	Glucose	Galactose	Pentoses	Methyl pentoses
5	<i>Leisecyphus taylori</i> (Hook)			Xylose, Arabinose	Methyl pentoses
6	<i>Mastigobryum trilobatum</i>			Xylose, Arabinose	Methyl pentoses
7	<i>Sphagnum trilobatum</i>			Xylose, Arabinose	Methyl pentoses
8	<i>Polytrichum commune</i>			Xylose	Methyl pentoses
9	<i>Stereocaulon pascale</i> L.....		<i>d</i> -Galactose	Pentoses	Methyl pentoses
10	<i>Peltigera aphitosa</i>		<i>d</i> -Galactose	Pentoses	Methyl pentoses
11	<i>Usnea barbata</i>	Glucose	<i>d</i> -Galactose	Pentoses	Methyl pentoses
12	<i>Cornicularia aculeata</i>		<i>d</i> -Galactose	Pentoses	Methyl pentoses

CYTASES IN THE VEGETABLE KINGDOM.

By the early investigators, Haubner (40), Henneberg and Stohman (41), Kühn, Aronstein, and Schulze (54), it was accepted without much question that, since cellulose disappeared from the alimentary tract of herbivora, it is digested like starch, and equally valuable as a nutrient. But after Tappeiner (78), in 1884, showed that cellulose could be decomposed by micro-organisms, and promulgated his theory that this was the only way to account for the disappearance of cellulose from the alimentary canal of ruminants, the matter fell into great dispute,¹ and the question is not yet definitely settled as to how cellulose is digested and what are the products of its digestion. A diligent search has been made for enzymes capable of attacking it (*cytases*), but so far, such cytases have been proved to exist only in plants and lower animals. Many of these so-called cytases act upon hemicellulose rather than true cellulose, and will be discussed in connection with the hemicelluloses, though it is not always possible to make a sharp distinction between the two. A careful review of the subject of cytases in plant physiology up to 1898, has been made by Biedermann and Moritz (34), from which it appears that the penetration of wood by the mycelia of moulds is due to such cytases, and that a powerful cellulose-dissolving enzyme has been derived from *Peziza sclerotium* by de Bary (37) and from another botrytis (presumably a *Peziza*) by Ward (84), while Brown and Morris (36) have described cytases existent in germinating grasses which dissolve their cell walls. That this is anything more than a diastatic enzyme is denied by Reinitzer (67); but Newcombe (64) considers the assumption of the identity of all cell-wall dissolving enzymes with diastase as far from justifiable. Bergmann (32) reports such cytases in hay and straw. Scheunert and Grimmer (71), on the contrary, find none in oats, corn, horse-beans, lupine seeds, buckwheat or vetch. Thus we see that even in the case of plants, these enzymes need to be isolated and identified before we can arrive at any satisfactory conclusions.

That cellulose can be dissolved by bacteria has been demonstrated for such forms as *Amylobacter butyricus*, *Vibrio regula* and *Clostridium polymyxa* (34). Omelianski (65) has described two organisms which ferment cellulose, and Ankersmit (31) finding Omelianski's bacteria on hay, has studied their behavior when introduced into the alimentary canal of the cow on its food. He finds that they do not increase

¹For a review of this discussion cf. Lohrisch (56).

in number during their passage through the digestive tract, and therefore concludes that they play a very inconsiderable rôle in the decomposition of cellulose. According to Van Iterson (81), certain aerobic bacteria, attacking cellulose, form from it products which nourish other forms (*spirilla*); certain anaerobes are also shown to attack it. Eberlein (38), finding in the first stomach of herbivora Infusoria which utilize cellulose for food, suggests that these protozoa, digested farther along in the alimentary tract, serve as means of transformation of cellulose into products which the animal can digest; but there is nothing to indicate that such forms occur in sufficient numbers to be worthy of much consideration.

Since 1906 three investigators have given the problem careful attention. Scheunert (68) has concluded from experiments *in vitro* that bacteria play an exclusive rôle in the solution of crude fiber in the coecal contents of horses, swine, and rabbits. He found that filtered coecal fluid acted on cellulose much less than unfiltered or simply strained coecal contents. This is contrary to the opinion of Hofmeister (45) and Holdefleiss (48), who attribute the phenomenon to the action of enzymes, and explain the loss of power occasioned by filtering as due to the effect of exposure to the air upon the enzymes. Lohrlich (57) has reported that fresh coecal fluid is effective in destroying cellulose while heated fluid is not. On the other hand, implanting the sterilized fluid with coecal bacteria and protozoa would not restore its activity. Coecal fluid kept at 38° C. any length of time gradually lost its cellulose-dissolving power, while that kept on ice remained active. v. Hoesslin and Lesser (47) have attempted to explain these apparent contradictions, and conclude from their own experiments that anaerobic bacteria are the most effective agents in cellulose decomposition in the intestine. Equal volumes of non-sterilized and sterilized coecal fluid of the horse, to which weighed amounts of cellulose had been added, were suspended in sterile physiological salt solution under practically anaerobic conditions and digested for periods of from 9 to 35 days. The disappearance of cellulose with the non-sterilized coecal fluid amounted to from 55.7 per cent to 71.2 per cent; with sterilized fluid, to from 6.2 per cent to 42.4 per cent. It was also found that the addition of 1-5 grams of dextrose would effectively protect the cellulose from digestion by the non-sterilized fluid, the bacteria preferring the more easily attacked carbohydrate. The gases evolved in these fermentations were characteristic of bacterial action, being chiefly methane, carbon dioxide, and hydrogen. The retarding effect of exposure to the air is explained by the theory that anaerobes are

the effective agents. So, also, the fact that Lohrisch was unable to get cellulose digestion in sterilized fluid again inoculated with unsterilized fluid is attributed to the medium's being an unfavorable one for the development of these organisms, inasmuch as the addition of peptones to similar preparations caused in several cases an increased decomposition. It seems fairly well established, therefore, that the action of the coecal fluid of the horse is due to enzymes of bacterial origin.

CYTASES IN LOWER ANIMALS.

There is no doubt that cytases occur in some of the lower forms of animal life. Biedermann and Moritz (34) found a powerful cellulase in the secretion of the liver of the common snail (*Helix pomatia*), and their observation was verified by E. Müller (61), also by Lohrisch (57) who reports two series of experiments in which snails fed tender lettuce leaves digested from 40.1 per cent to 81.6 per cent of the cellulose present. On the other hand, Müller (61) could not verify Knauthe's report of a cellulase in the hepato-pancreas of the carp (50); Pacault found none in the saliva of *Helix pomatia* (66); and Biedermann none in the digestive juice of the meal worm (*Tenebrio molitor*) or of the cabbage worm (*Pieris brassica*) (34). Biedermann also examined the faeces of the cabbage worm microscopically and found unaltered particles of leaves, from which he concluded that much of the plant food eaten is excreted unchanged. Lohrisch (56) has obtained similar results with caterpillars of sphinx moths (*Sphinx euphorbiae*), not only in experiments with intestinal juice *in vitro*, but also in feeding experiments in which the cellulose was quantitatively excreted.

Sellière (75-76) has recently added some interesting contributions to this subject, showing that cotton treated in various ways; namely, that recovered after solution in Schweitzer's reagent, that treated with concentrated zinc chloride, or with 25 per cent caustic alkali hot or cold until the fibers are swollen, and subsequently washed with 1 per cent acetic acid and water, is attacked by *Helix pomatia* much more readily than the untreated substance. Subsequent drying of the treated cotton diminished its digestibility somewhat, suggesting that the physical condition of the cellulose is a definite factor in its utilization. Sellière believes that only the more tender portions of plant cellulose are attacked by the digestive juice of this snail. It would seem that the previous treatment of the cellulose is a factor to be kept in mind in the interpretation of the results of feeding experiments.¹

¹Cf. the experiments on cellulose utilization in the dog, p. 263.

CYTASES IN HIGHER ANIMALS.

There is at present no proof of the existence of cytases in any of the higher animals. The literature on the subject has been exhaustively reviewed by Bergmann (32), and Lohrisch (55, 56, 57) and it appears that there is no cellulase in the saliva or pancreatic juice of swine, horses, cattle, or sheep. The old observation by MacGillawry¹ (cited by Biedermann and Moritz(34) that a cytase can be extracted from the vermiform appendix of the rabbit has been denied by Zuntz and Degtiareff (88). Schmulewitsch's² statements (also cited by Biedermann and Moritz) are worthless because he employed no antiseptics. E. Müller (61) found no sugar formed from the decomposition of cellulose in the stomach of the goat, and Lusk (59) observed no increase in sugar elimination after feeding a phlorhizinized dog 20 grams of cauliflower, or a phlorhizinized goat 10 grams of paper. Lohrisch (57) fed pure cellulose (5-20 grams) to a phlorhizinized rabbit and found that it had no marked influence on the sugar output, and no nitrogen-sparing effect. Scheunert (70) has made further investigation on the action of the saliva and salivary glands in sheep, and confirms the earlier experiments with the saliva of this animal. On the other hand, Sellière (77) reports that the specially treated cellulose mentioned above is converted into dextrose by the intestinal secretions of the guinea pig in some instances.

Practically nothing is known concerning the way in which cellulose disappears from the alimentary tract of man. Schmidt and Lohrisch (73) fed pure cellulose to diabetics and observed a disappearance averaging 77.7 per cent, and no increase in the elimination of sugar. They believe that most of it is absorbed in soluble form and not destroyed by fermentation in the intestines. Lohrisch, having fed cellulose in various diseases of the alimentary tract,³ calls attention to the fact that in constipation, where there is the least bacterial action, the utilization of cellulose is highest, while in fermentation dyspepsia, in which one might expect a marked disappearance, the utilization is lowest. He therefore considers the digestion of cellulose as due at least in part to enzymes.

¹Archiv Neerland, Vol. XI.

²Über das Verhalten der Verdauungssäfte zur Rohfaser der Nahrungsmittel. Bulletin de l'Academie Imperial de St. Petersburg, 1879.

³See results, p. 264.

DIGESTION AND UTILIZATION OF CELLULOSE BY ANIMALS.

The literature on the digestion of cellulose up to 1909 has been so exhaustively reviewed by Lohrisch that it is unnecessary to enter into a detailed discussion of it. From tables (55) showing the results of all previous experiments on the utilization of crude fiber in herbivora, carnivora, and birds, it appears that in the case of herbivora, especially ruminants, 20–28 per cent of the crude fiber ingested with food disappears from the alimentary canal; that in case of carnivora¹ and birds² there is no utilization whatever. Lohrisch (56) himself reported three experiments in which dogs were fed pure cellulose and digested 31.1 per cent, 37.45 per cent and 5.4 per cent respectively, but Scheunert and Lötsch (72) repeating Lohrisch's work with a somewhat different method of determining cellulose found that the administration of 40 grams of prepared white cabbage, containing 7.37 grams of pure cellulose, resulted in the recovery of the total amount ingested. Cooking the cabbage in bouillon did not increase its digestibility. They attribute the apparent utilization in the preceding experiment to destruction of cellulose by the reagents used for its purification. Since the publication of their paper, Lohrisch has repeated his work with the dog (57), and reports complete recovery of the cellulose fed. He explains the error in the earlier investigation as due to the fact that the ingested cellulose was twice subjected to purification (before feeding and in faeces) with consequent increase in percentage of loss, which was not taken into account. He points out the inevitable loss of some cellulose by any method at present in use for its determination, and defends his own as sufficiently accurate for all practical purposes if conditions are carefully observed.³

¹The only experiments on record are by Voit and Hoffmann on the dog and by von Knieriem on the hen.

²Experiments by Weiske on the goose, and by von Knieriem on the hen.

³Lohrisch used the method of Simon and Lohrisch, in which the cellulose is dissolved by heating for an hour on a water bath with 50 per cent potassium hydroxide, then adding $\frac{3}{4}$ cc. of 30 per cent hydrogen peroxide, and digesting from $\frac{1}{2}$ to $\frac{3}{4}$ hour longer if necessary. The cellulose is then precipitated by adding to the solution one half its volume of 96 per cent alcohol and 6–7 cc. of concentrated acetic acid; filtered off, washed with water, dilute acetic acid, alcohol and ether, dried and weighed.

Scheunert and Lötsch mix the substance to be analyzed with 100 cc. of cold water, add 100 grams of potassium hydroxide and heat for an hour on a water bath, then filter through a hard filter paper, wash the residue on the paper with boiling water till only a trace of alkali remains, transfer it to a beaker and thence to a weighed

Cellulose digestion in the dog has been almost simultaneously studied by v. Hoesslin (46). Two dogs on a meat-fat diet to which was added daily 2 grams of specially prepared white cabbage (containing 63.25 per cent of pure cellulose), for five periods of five days each, excreted on the average 99.7 per cent and 94.5 per cent respectively. This long experiment is significant as showing no adaptation of the digestive glands to the type of food. By these independent workers it seems now well established that the dog is unable to utilize cellulose.

Hoffmann (42) has just published the results of some investigations on the influence of cellulose on the nitrogen balance and on phlorhizin-diabetes in the rabbit, from which it appears that after ingestion there is no increase of sugar excretion, and no glycogen formation, yet he thinks that cellulose and hemicelluloses have a favorable influence in phlorhizin-diabetes.¹ It seems to follow from this, that even in case of herbivora cellulose is not utilized in the manner customary for starch and sugar.

DIGESTION AND UTILIZATION OF CELLULOSE BY MAN.

A similar tabulation of results of feeding experiments on man, shows that cellulose is not so well utilized as by herbivora, but does disappear in appreciable amounts. With one exception, the cellulose in all these experiments was administered as crude fiber. Hofmeister (43) fed pure cellulose and reported 75.7 per cent soluble cellulose and 5.6 per cent insoluble cellulose digested. König and Reinhardt (53) added to a diet rich in protein and fat, but free from cellulose, in several experiments, green peas and ripe shelled peas, red cabbage, white

filter, on which it is washed successively with hot water, dilute acetic acid, hot water, alcohol and ether, and finally weighed.

Scheunert and Lötsch claim that by Lohrlich's method the cellulose is altered in character, and as much as 40 per cent lost in the process; and that subsequent treatment of the recovered material causes an even greater per cent of loss, while by their method the loss in the first case is not over 6.8 per cent, and that in the second case even less.

For the details of this controversy over method see the following: Simon and Lohrlich; *Zeitschrift für physiologische Chemie*, Vol. 42, p. 55, (1904). Scheunert; *Berliner tierärztliche Wochenschrift*, No. 47, p. 826, (1909). Scheunert and Lötsch; *Ibid.*, p. 867, (1909); also *Biochemische Zeitschrift*, Vol. 20, p. 10, (1909); and *Zeitschrift für physiologische Chemie*, Vol. 65, p. 219, (1910). Scheunert and Grimmer; *Berliner tierärztliche Wochenschrift*, No. 48, p. 152, (1910). Lohrlich; *Zeitschrift für physiologische Chemie*, Vol. 69, p. 143, (1910).

¹Unfortunately the original paper was not accessible.

beans, graham and soldiers' bread and found 30.27 per cent to 76.79 per cent of the added cellulose digested. Lohrisch (55) finds that the cellulose of a common vegetable diet disappears from the alimentary tract in large amounts, the actual quantity varying with the age, source and tenderness of the cellulose. Thus he finds that for normal individuals, of cellulose from lentils, 45 per cent is digestible; from kohlrabi, 79.1 per cent; from white cabbage, 100 per cent. Under abnormal conditions in the digestive tract, he has obtained the following results:

CONDITION.	CELLULOSE UTILIZATION IN PER CENT.
Normal.....	57.9
Chronic Constipation.....	81.4
Fermentation Dyspepsia.....	37.8
Gastrogenic Diarrhea.....	29.5
Fatty Faeces in Icterus.....	27.8
Fatty Faeces in Disease of Pancreas.....	20.9

According to Lohrisch, two diabetics on a cellulose-free diet, to which white cabbage was added in quantities to yield about 6 per cent of cellulose per day, digested 68.6 per cent and 84.5 per cent respectively, without increased output of sugar in the urine.

Since the only way to determine definitely the energy value to the organism of such amounts of cellulose as are absorbed, is by means of respiration experiments, Lohrisch (57) has performed such an experiment on man, using the Zuntz-Geppert apparatus. In fasting, the respiratory quotient averages about 0.76. After ingestion of carbohydrates such as starch, it rises gradually in two to three hours, to 0.9-1.0, and when the carbohydrate has been consumed, sinks again to a lower level. Since the respiratory quotient for fat is 0.7 and for protein about 0.8, it is possible to determine in this way to what extent the carbohydrate replaces protein and fat in metabolism. Hence if cellulose is absorbed and oxidized as a carbohydrate, the respiratory quotient should rise. If it is decomposed by bacteria, the respiratory quotient should not rise, since the theoretical respiratory quotient for fatty acids, such as butyric and acetic, is, according to Munk (62) and Mallèvre (60), 0.6 and 0.5 respectively. Now Lohrisch, feeding a man moist cellulose equivalent to 73.6 grams of dry substance, of which 25 per cent was digested (18.5 grams) obtained the following results:

NUMBER OF EXPERI- MENT.	BEGINNING OF EX- PERIMENT.	DURATION OF EX- PERIMENT IN MIN- UTES.	VOLUME INHALED PER MINUTE.	CO ₂ CONSUMPTION.	CO ₂ PRODUCTION.	R. Q.	O ₂ CONSUMPTION PER MINUTE.	CO ₂ PRODUCTION PER MINUTE.	O ₂ CONSUMPTION.	CO ₂ PRODUCTION.	AFTER BEGINNING OF CELLULOSE INGES- TION.
	Hour.		ccm.	Per cent.	Per cent.		ccm.	ccm.	Per cent.	Per cent.	Hours.
1	6.43	24	4695	4.14	3.33	0.804	194.37	156.34			
2	7.25	27	3981	4.77	3.68	0.772	189.89	146.50			
Av.							192.13	151.42			
3	10.11	26	4237	4.59	3.37	0.734	194.47	142.79	+1	-5½	2
4	11.27	27	4230	4.43	3.40	0.792	187.38	143.82	-2½	-5	4
5	12.36	24	4649	4.36	3.23	0.740	202.69	150.16	+5½	-1	5
6	1.30	24	4768	4.27	3.10	0.726	203.49	147.81	+6	-2½	6
7	2.58	25	4390	4.63	3.22	0.700	203.26	141.36	+6	-6½	7
8	4.40	22	5041	4.44	3.10	0.700	223.82	157.78	+16½	+4	9
9	6.22	23	4859	4.35	3.01	0.692	211.37	146.26	+10	-3½	11
10	7.53	21	5290	4.15	3.01	0.725	219.53	159.23	+4	+5	12

The respiratory quotient attains its highest value in the fourth hour, instead of the second or third, showing that cellulose is absorbed more slowly than starch. The rise is too slight to indicate that cellulose exercises any considerable protein- or fat-sparing effect. It is unfortunate that the amount of cellulose absorbed was so small. It is striking that the O_2 -consumption decreases at the very time that the respiratory quotient rises, and the CO_2 -production scarcely increases. Lohrisch interprets this as indicating that the increased O_2 -consumption required for oxidation of the cellulose is compensated by a sparing of protein and fat. The differences seem too small to draw any satisfactory conclusions as to the energy value of cellulose. The low respiratory quotient in the later hours of the experiment, together with the increased O_2 -consumption, indicates the utilization of some of the cellulose in the form of fatty acids. We must bear in mind that no formation of sugar or glycogen from cellulose, in men or animals, has been demonstrated. Further investigations would seem to be necessary before we can agree with Lohrisch in saying, "*Wir wissen, dass Cellulose und Hemi-cellulosen vom Menschen reichlich verdaut werden, wir haben allen Grund anzunehmen, dass ihre Verdauung nach Analogie der Stärke abläuft . . . Die resorbierten Mengen werden im menschlichen Organismus vollständig verbrannt. Dabei wird Eiweiss und Fett von der Verbrennung geschützt.*" In any event, the quantities of cellulose which the alimentary tract of man is capable of absorbing are, apparently, too small for it to play a rôle of any importance in the diet of a normal individual.

OCURRENCE AND NATURE OF PENTOSANS.

The anhydrides of the 5-carbon sugars are collectively designated as pentosans. These are not reported to occur in the animal kingdom, but the pentose sugars are found forming a part of the nucleic acid radical of the nucleo-protein molecule. In the vegetable kingdom, pentosans are very widely distributed, as has been shown by many investigators, especially Tollens and his pupils.¹ They occur in all kinds of plants, from the lowest to the highest, and are limited to no

¹ Tollens, Landw. Vers., V. 39, p. 401, (1891); Tollens, Jour. f. Landw., Vol. 44, p. 171 (1896).

For an exhaustive review of the literature on the occurrence of the pentosans see v. Lippmann, Chemie der Zuckerarten, 3rd Edition, Vol. I, pp. 44-60; 116-123; and Czapek, Biochemie der Pflanzen, Vol. I, pp. 537-545 (1905).

particular organ or tissue, being found abundantly in roots, stems, leaves or seeds.

In regard to solubility in water, pentosans show all possible variations. De Chalmot (108) found them present in the watery extract of the leaves of many plants; Winterstein (167) in the somewhat mucilaginous hot water extract of the seeds of *Tropaeolum majus*; Schulze (146), in both soluble and insoluble form in the cotyledons and endosperms of the seeds of *Lupinus luteus* and other legumes, where they are doubtless stored as reserve material for the growing plant; and in the cell walls of the mature plants, where in most cases they approach true cellulose in character. It is difficult to differentiate these highly resistant pentosans of the cell wall, which are commonly included in the term crude fiber, from the ligno-celluloses and oxycelluloses also found there, which as Cross, Bevan and Beadle (104) have shown,¹ are like true pentosans in yielding furfural on distillation with dilute hydrochloric acid. Besides hemicelluloses yielding pentoses (*xylose* and *arabinose*) exclusively, occur many yielding also methyl-pentosans (*fucose*, *rhamnose*). These yield on distillation with dilute hydrochloric acid, methyl-furfural, which is precipitated by phloroglucin, and hence included in quantitative estimations of pentosans by the method of Tollens and Kröber (121). The distribution of methyl-pentosans has been studied especially by Tollens and his pupils. Japanese "Nori" (*Porphyra laciniata*, *Laminaria*, and other seaweeds) (129), tragacanth and many other gums (163) contain fucosan. Rhamnose occurs also widely distributed in the plant kingdom, but more frequently in the form of a glucoside. Röhmann (134) reports a rhamnosan in *Uva lactuca*.

It is a very common thing to find pentosans and hexosans occurring together. In fact, it is absolutely impossible, in treating of hemicelluloses, to draw any sharp dividing lines, for they are not only intimately associated, but frequently chemically combined. Schulze (146) has given the name paragalactan to the carbohydrate yielding arabinose and galactose, which occurs in the seeds of many legumes. Winterstein (167) finds galacto-xylan in the water extract of *Tropaeolum majus*, and numerous other examples of such combinations might be cited.

A class of substances to which has been given a distinctive name because of their peculiar gelatinizing property, is the Pectins. As Czapek² remarks, "It is uncertain whether they form a definite

¹For further details see v. Lippmann; *Chemie der Zuckerarten*, Vol. I, pp. 160-169.

²Die Pektin-Substanzen; Czapek, *Biochemie der Pflanzen*, Vol. I, p. 545.

class of cell wall substances, or whether they should be classified as 'hemicelluloses' or 'pentosans.'” In 1868, Scheibler (141) found a sugar which he called pectinose, but which was later shown to be arabinose (142). In 1875, Reichardt (132) obtained a pectin body from carrots and beets, which he called 'pararabin,' expressing the view that pectins should hardly be considered as a special class of carbohydrates. Tromp de Haas and Tollens (160) have found from numerous analyses, that the pectins do not differ from other carbohydrates in their relative proportions of hydrogen and oxygen so much as earlier workers supposed, and hence they may be classified with other hemicelluloses according to the products of their hydrolysis (pentoses; galactose and other hexoses). Cross (106) believes them to be allied to the ligno-celluloses. The whole matter is still in a state of uncertainty. Herzfeld (116) has shown that arabinose can be obtained from most pectins, and consequently they have been included among the pentosans, though from the frequency with which they yield galactose, they might equally well be discussed with the galactans. According to Czapek while pectins occur frequently in phanerogams, ferns and mosses, their presence in algae is doubtful, although it is possible that soluble carbohydrates of algae yielding arabinose or galactose are closely related to the pectins of other plants.¹

RÔLE OF THE PENTOSANS IN PLANT PHYSIOLOGY.

Comparatively little is known of the rôle of pentosans in plant physiology. De Chalmot's (108) observation that they decrease in quantity in seeds — peas and corn — during germination, and reappear in the stems and roots of the growing plant, would seem to indicate that they form a part of the reserve material in the seed; but Schöne and Tollens (145), finding no diminution in the amount of pentosans in grains during germination, but rather a slight increase, declare that they do not belong to the reserve-stuff of the seed; so the question may be regarded as still unsettled. Changes in the relative amounts of pentosan in plants at different stages of growth, studied by Cross, Bevan and Smith (105), Götze and Pfeiffer (113), Calabrèsi (98), and others, show that the increase of pentosans runs parallel to the formation of the skeletal substance; and have led to the idea that they arise through the transformation of a part of the cellulose, and along with lignin and cutin, take part in wood formation. Ravenna and Cereser

¹Cf. also Bigelow, Gore, and Howard (92).

(131) find in the case of dwarf beans that when the food is wholly dextrose administered to the leaves, pentosans increase greatly, especially in the light, and that when the functioning of chlorophyll is prevented for long periods the amount of pentosans decreases. They conclude that the simple sugars exert a preponderating influence in pentosan formation, and that these serve as a reserve material when the plant has exhausted its more readily available food materials.

PENTOSANASES IN THE VEGETABLE KINGDOM.

Our knowledge of enzymes inverting pentosans is meager, and rather indefinite. The action of such forms as *Hymenomyces* upon wood seems to be of chemical nature. At any rate it is evident (107-146) that they are able to utilize xylan. Bourquelot and Hérissé (95) have isolated an enzyme from malt diastase which produces reducing sugar from pectins, and call it pectinase. This is not to be confused with the so-called pectase which causes the coagulation of pectin bodies. Bigelow, Gore and Howard (92) also find that the enzymes of *Aspergillus* partially hydrolyze the pectin of gentian root. According to Harrison (114), *Bacillus oleraceæ* produces a cytase capable of dissolving the cell walls of potatoes, turnips, cauliflower and allied plants, which acts particularly on the middle lamella, the supposed seat of pectin.¹ The latter is not an inverting enzyme. In Persian Berries (*Rhamnus*) (162), in *Penicillium glaucum*, and *Botrytis cinerea* (90), an enzyme (*rhamnase*) has been found which splits off rhamnose from some of its glucosides (*rhamnetin* and *rhamnazin*). An early observation of the presence of rhamnase in the rutin of garden rue was made by Bornträger (94). That some of the so-called cytases described under cellulose² may act on pentosans seems possible, but there is no direct evidence that such is the case. On the contrary, Cross and Bevan (105) believe that pentosans once formed in the plant, remain thenceforth unaltered.

Tollens and Glaubitz (159) assert that the pentosans do not undergo lactic or butyric acid fermentation, and are otherwise unaffected by yeast, as has also been shown by Lintner and Düll (125). The pentosans are very resistant toward the action of bacteria. Slowtzoff (154) found that a small amount of pure xylan in a putrefying mixture,

¹Cf. Czapek, *Biochemie der Pflanzen*.

²Cf. Biedermann and Moritz (34), Brown (35), Brown and Morris (36), Bergmann (32), Grüss (184), Newcombe (64).

kept at a temperature of 40° C., did not entirely disappear from the solution before the ninth or tenth day. Two widely distributed fermenting agents acting on hemicellulose (*Bacillus asterosporus* Arth. Meyer, and *Bacillus clostridieforme*, Burri and Ankersmit), studied by Ankersmit (89), are said by him to occur in insufficient numbers to make their activity of any significance in the alimentary canal of the cow.

PENTOSANASES IN LOWER ANIMALS.

Extensive investigations regarding the occurrence of pentosan-splitting enzymes in lower animals, have been made by Sellière since 1905. The secretion of the hepato-pancreas of the common snail (*Helix pomatia*) not only digests cellulose *in vitro*,¹ but also xylan, according to this writer (148). In feeding experiments, analyses of the food (oak wood) and excreta of these xylophages showed a higher percentage of xylan in the former than in the latter (149). Hence xylan must have been digested. In 1907, he showed that pentoses were actually liberated and absorbed, by testing the blood of these snails, which gave the phloroglucin reaction (151). That sugar can be found in their blood is denied by Couvreur and Bellion (99), but this Sellière attributes to the fact that the sugar content is much less than in higher animals, and hence has been entirely overlooked.

Xylanase also occurs in other species of snail (150) such as *Helix aspera* Müll., *Helix nemoralis* L., *Limax arborum* Bouch., *Limax variegatus* Drap., *Arion rufus* L., *Patella vulgata* L., *Littorina litorea* L., *Littorina littoralis* L., and in a representative of the *Coleoptera*, *Phymatodes variabilis* L. The presence of a xylanase in *Patella vulgata* and the *Littorinae* is especially significant, as their food consists in pento:an-rich algae. Sellière (150) and Pacault (130) have independently discovered a xylanase in the salivary glands of *Helix pomatia*. According to Röhmann (134), *Aplysia*, which subsist largely upon *Ulva lactuca*, do not, digest the soluble methyl-pentosan (*rhamnosan*) present in this alga. He finds this carbohydrate present in the glands of the midgut, but regards it as a food residue.

PENTOSANASES IN HIGHER ANIMALS.

There have been only a few investigations as to the presence in higher animals of enzymes hydrolyzing pentosans. Slowtsoff (154)

¹Cf. Biedermann and Moritz (34).

found that pure xylan was not digested by saliva, gastric or pancreatic juice, but could be gradually hydrolyzed (in two or three days) by 0.2 per cent hydrochloric acid. Bergmann (91) digested pure xylan with extracts of the intestines of many animals (hen, goose, guinea-pig, sheep, ox, horse), and of the vermiform appendix of rabbits, but in no case found a xylanase. These experiments were performed with suitable antiseptics and controls in all cases. An old experiment by Fudakowski (112), attributing an inverting action upon gum arabic to pepsin, and another by Schmulewitsch (144), attributing such an action upon crude fiber to pancreatin, must be disregarded, as no antiseptics whatever seem to have been used. According to Sellière (152), neither the pancreatic juice of rabbits, nor a mixture pancreatic and intestinal juices, will hydrolyze xylan. Negative results were also obtained by him with macerated intestines of these animals. On the other hand, chloroform extracts of the intestinal contents of rabbits and guinea-pigs fed fresh hay and bread, produced pentoses in a 5 per cent xylan solution after 48 hours digestion at 37 degrees C., while negative results were obtained with boiled controls. This indicates that the enzymes causing hydrolysis were of bacterial origin, a conclusion substantiated by later work of the same author (153). No xylanase was detected in the excreta of carnivora such as the lion, panther, and wolf. From a centrifugalized extract of human faeces and soluble xylan, digested under aseptic conditions, xylose was obtained after 15-20 hours; but in meconium of calves and human beings in which bacteria were absent no xylanase could be found, although the intestinal glands were functioning. McCollum and Brannon (126) have shown that in the case of the cow intestinal bacteria destroy pentosans under anaerobic conditions, the degree of destruction varying with the kind of plant. Corn, wheat and oat feeds were incubated with fecal bacteria of this animal, and digestions continued 14 days in atmospheres both of carbon dioxide and hydrogen, with the following average results:

MATERIAL.	ATMOSPHERE.	PER CENT OF PENTOSANS DISAPPEARING.
Corn Fodder.....	CO ₂	51.78
Corn Fodder.....	H	76.13
Wheat Straw.....	CO ₂	28.09
Wheat Straw.....	H	37.99
Oat Straw.....	CO ₂	30.66
Oat Straw.....	H	54.00

From this review it is evident that the presence of pentosanases in the higher animals has not yet been demonstrated.

DIGESTION AND UTILIZATION OF PENTOSANS BY ANIMALS.

In the case of men and animals subsisting on a mixed diet, the hexoses and their derivatives so overbalance the pentosans, under normal conditions, that the utilization of the latter is a question of theoretical rather than of practical importance. But in the case of herbivora, limited to a diet in which pentosans occur in considerable amounts, the extent of pentosan utilization becomes a question of economic importance. It is not surprising to find, therefore, that since the development of satisfactory methods of quantitative determination, a considerable number of investigations have been made upon such utilization by animals. The results of these experiments are shown in tables on pages 274 and 275.

The results in these experiments were obtained by analysis of food and faeces. Lindsey (123) Götze and Pfeiffer (113) and Tollens (157) found no measurable amount of pentoses or pentosans excreted in the urine of sheep, but Neuberg and Wohlgemuth (128) state that pentosans always occur in the urine of rabbits, only disappearing when the vegetable diet is compensated by pentose-free material. They report that 9 per cent of soluble araban (cherry gum) fed to rabbits was excreted in the urine. Slowtzoff (154) found 1.4-4.5 per cent of xylan in the urine of rabbits, but no reducing sugar. He also found that if the animal were killed shortly after xylan feeding, xylan could be detected in blood, liver and muscles. Hence xylan must have been absorbed from the digestive tract.

The feeding experiments show that herbivora digest, on the average, 55-60 per cent of the pentosans in their diet, but since no animal enzymes hydrolyzing pentosans have been demonstrated, and there is always the possibility of bacterial decomposition in the intestines, the most conclusive experiments as to the actual nutritive value are those of Kellner (118) with the respiration calorimeter. From the slight difference in loss of potential energy, when the furfural-yielding rye straw preparation was substituted for starch, he concludes that furfural-yielding substances participate in the formation of fat in the animal body.

DIGESTION AND UTILIZATION OF PENTOSANS BY MAN.

We have seen that pentosans can be digested by herbivora to a considerable extent. Can they be digested by man? The only feeding experiments on record are by König and Reinhardt (120).

In 1902, they conducted researches on two men whose main diet consisted of meat and butter or other fat, and beer; to this, in the various experiments, were added respectively (along with sugar, butter, beef extract, etc., used in preparing them) the following substances:

Experiment I. Green Peas. Experiment II. Ripe Shelled Peas. Experiment III. Red Cabbage. Experiment IV. Canned White Beans. Experiment V. Soldiers' Bread. Experiment VI. Graham Bread.

From analyses of food and faeces the following results were obtained:

TOTAL PENTOSANS IN GRAMS.	EXP. I.	II.	III.	IV.	V.	VI.
In Food	15.55	23.15	14.01	12.80	52.64	41.26
In Faeces	0.79	0.59	0.70	1.12	8.66	4.06
Per cent not utilized, estimating Pentosans in Beer as unutilized.....	5.08	2.55	5.0	8.75	16.45	9.84
Total per cent not digested.....	7.47	3.24	7.75	14.32	20.24	12.97

Hence we see that of the total pentosans in the diet 3.24-20.24 per cent were excreted. Only a little furfural-yielding substance was found in the urine. From the small percentage recovered in these experiments, König and Reinhardt (120) conclude that the pentosans are to a high degree utilized by man, but they take no account of possible destruction by bacteria.¹

Since pentosans do disappear from the alimentary tract of men and animals, it behooves us to consider whether, on the assumption that they are hydrolyzed like starch, the pentose sugars so produced are as well utilized as dextrose. König and Reinhardt (120) found some furfural-yielding substance in the urine, and Blumenthal (93) observes that after eating huckleberries, cherries and prunes, pentosans are excreted, but no reducing sugar. Cominotti (100) finds pentoses absent from the urine of man on a meat diet, but always present on a mixed diet. He agrees with König and Reinhardt that the output in the urine is small compared with the amount of pentosans in the food, and proposes to investigate the possibility of glycogen formation from pentosans.

The behavior of pentoses in the body has been exhaustively reviewed by Neuberg(127).² It appears from the work of Cremer (102, 103),

¹ Cramer (101) has shown (according to a recent review, the original paper was not accessible) that bacteria are essential to hemicellulose transformation.

²For a recent discussion of the absorption and utilization of pentoses see A. Magnus-Levy, Oppenheimer's Handbuch der Biochemie der Menschen und der Tiere, 1909, Vol. IV, pp. 395-407.

NAME OF INVESTIGATOR.	DATE.	SPECIES OF ANIMAL.	MATERIAL FED	AVERAGE PER CENT PENTOSANS DIGESTED.
Stone (155).....	1892	Rabbits	Corn meal, Wheat bran	40-60
Stone and Jones (156).....	1893	Sheep	Various kinds hay and grasses	60.3
Weiske (166).....	1895	Sheep	Oats	65.1
		Rabbits	Oats	53.8
		Rabbits	Wheat bran	53.9
Lindsey and Holland (124).....	1895	Sheep	Hay and different grasses	55-90
Götte and Pfeiffer (113).....	1896	Sheep	Luzerne hay, Cherry gum	54.3
		Sheep	Luzerne hay	44.6
Sherman (143).....	1897	Steer	Wheat bran	66.2
Fraps (110).....	1900	Sheep	Timothy hay	53.9
			Feeding stuffs	68.5
			Average all materials	64.2
Kellner and Köhler (118).....	1900	Oxen	A 3 Kg. Rye straw extracted with dilute sodium hydroxide, containing 31.1% furfural-yielding substance added to a basal ration	Loss of potential energy 14.0%
			B 2.5 Kg. starch added to basal ration	Loss of potential energy 10.1%
Slowtzoff (154).....	1901	Rabbits	Pure xylan	55.78
Weiser (164, 165).....	1903	Oxen	Hay, rape	63.4
		Horses	Rape, corn, oats	45.5
		Swine	Rape	47.9
		Sheep	Rape	55.1
		Fowls	Corn, rape	23.9
Lindsey (123).....	1903	Sheep	Hay, grains, by-products	40-90

Rudzinski (136)	1904	Sheep	A Rye straw + starch and sugar B Straw + grain and staff + starch and sugar C Threshed straw D Straw + 1.57 lb. sugar and 6.29 lb. starch per Kg. of body weight Oats and hay	46.82 39.89 70.20 12.56 (With coccum) 17.3-50.0 (Without coccum) 13.2-40.0 Heated Ordinary 22.26 19.91 29.30 19.72 38.95 36.07 45.69 33.54 (With coccum) 35.8 (Without coccum) 27.6
Zuntz-Utzjanzew (168)	1905	Rabbits	A Wheat straw B Wheat straw C Meadow hay D Meadow hay Wheat and hay Oats and hay or oats alone Hay cut before blooming Hay cut in bloom Hay cut after blooming Pea bran Buckwheat bran Barley bran Wheat bran Wheat bran	82.06 68.52 53.6 94.01 54.75 51.45 57.77 49.7
Bergmann (91)	1906	Rabbits	A Wheat straw } Whole wheat } Wheat gluten } B Oat straw } Rolled oats } C Corn meal } Corn stover } Corn gluten feed }	50.86 54.69
Utzjanzew (161)	1907	Rabbits		67.21
König (119)	1907	Sheep		
		Swine		
		Rabbit		
McCullum and Brannon (126)	1909	Cow		

Ebstein (109), Frantze (111), Neuberg and Wohlgemuth (128), Salkowski (137), v. Jacksch (117), Lindemann and May (122), Brasch (96) and others, that the pentoses and methyl-pentoses (*rhamnose*) are excreted more readily than the hexoses; that they exert an unfavorable effect in diabetes; and that there is no evidence of their acting as glycogen-formers in man. Consequently, even if further experiments justify König and Reinhardt's conclusions, the pentosans must apparently still play a very small part in the nutrition of man.

OCURRENCE AND NATURE OF GALACTANS.

Next to the pentosans, no hemicelluloses seem to be so widely distributed as the galactans; both occur together in the plant cell, and often in a more or less intimate chemical combination. The pure galactans, i.e., those yielding exclusively galactose upon hydrolysis, have been differentiated into several classes, chiefly by differences in solubility or specific rotation, namely:

1. α -galactan, so named by Müntz (199), the first to identify galactan as an anhydride of galactose; it composes 42 per cent of luzerne seeds and occurs also in beans, barley, and malt.

2. β -galactan, isolated from the lime residues in the sugar beet industry by Lippmann (192).

3. γ -galactan, first isolated from Chinese moss (*Sphaerococcus lichenoides*) by Payen (262), in 1859, and by him called "gelose." He also identified it in agar-agar¹ (*Gelidium corneum*) and other algae. The carbohydrates of agar-agar were again studied by Reichardt in 1876, who obtained a substance of the formula $C_{12}H_{22}O_{11}$ and considered it identical with the "pararabin" which he found in carrots and beets.² In 1881 and 1882, Greenish (180, 181) investigated the carbohydrates of *Fucus amylaceus* (Ceylon agar-agar) and obtained on hydrolysis a sugar-yielding mucic acid (galactose). From *Sphaerococcus lichenoides* he also obtained a substance resembling Payen's "gelose." In 1884, Bauer (169) showed that agar-agar yields galactose; and in 1905, König and Bettels (190) gave the following percentage composition of Japanese agar-agar from *Gelidium*:

	Per cent.		Per cent.
Galactans	33	Ash	3.5
Water	20	Pentosans	3.1
Protein	2.6	Crude fiber	0.4

¹The term agar-agar is applied to the hot water extract of various red algae, mainly species of *Gelidium*.

²See Pentosans, p. 268.

Another species of marine algae in which galactan has been fully identified, is *Chondrus crispus* (Irish moss). This is also a red alga. C. Schmidt (210) first examined it, in 1844; he demonstrated that the gelatinizing substance was a carbohydrate and yielded sugar on hydrolysis. Flückinger and Mayer (178), in 1868, discovered that the water extract of this alga yielded considerable mucic acid. In 1875, Bente (171) obtained levulinic acid from the products of its hydrolysis, and in 1876, reported that it yielded a non-crystallizing syrup (172). The first quantitative analysis was made by Hädike, Bauer and Tollens (185), who showed that the water extract yielded mucic acid corresponding to about 25 per cent of galactan. Sebor (220), in 1900, found in the products of hydrolysis, glucose, fructose and a small quantity of pentose. These observations were verified by Müther (200) in 1903, who further identified the galactose as a *d*-galactose. From the large yield of mucic acid, the water extract of *Chondrus* may therefore be regarded as chiefly galactan, together with some dextran and levulan, and a very little pentosan; groups which, according to Hädike, Bauer and Tollens (185), may be partly or entirely bound into ester-like compounds.

Examples of galactans occurring in combination, or close association with other hemicelluloses are numerous. Lupeose, from luzerne seeds, originally called β -galactan, yields 50 per cent galactose and 50 per cent fructose (214). The tuberous roots of *Stachys tuberosa* contain a soluble crystallizable carbohydrate yielding 37 per cent mucic acid, along with an unidentified sugar (225). Para-galactan (*galacto-araban*) forms a large proportion of the reserve material of many seeds.¹ Rothenfusser (204) finds that the mucilaginous extract of flaxseed yields equal parts of pentosans and hexosans, the latter being mainly galactose. Galactans and pentosans, as already indicated,² occur together in many lichens and algae, and also in the pectins.³ Hérissé (187) has shown that the "galactine" of Müntz (199) yields equal parts of galactose and mannose. Galacto-mannans also frequently occur in the reserve material of seeds, as in those of the date and other species of palm, and in coffee beans; in the American honey

¹Cf. Schulze (215), Schulze, Steiger and Maxwell (217), Schulze and Castoro (218), Castoro (176), and Goret (179). Also Schulze and Godet, *Zeitschrift für physiologische Chemie*, V. 61, p. 279, for a very complete review of the work of Schulze and his pupils.

²See *Chemical Nature of Lichens and Algae*: König and Bettels (8), Escombe (6), K. Müller (11), Ulander (26).

³Cf. *Pentosans*, p. 268.

locust (*Gleditschia triacanthus*), Goret (179) found the albumen to yield 66-70 per cent galactose and 22-23 per cent mannose; he has shown, in fact, that the carbohydrate reserve of almost all seeds with horny albumen consists largely of a mixture of mannans and galactans.¹

GALACTANASES IN THE VEGETABLE KINGDOM.

The hydrolysis of the paragalactan of lupine seeds during germination was first observed by Schulze and his co-workers. That ordinary diastatic enzymes do not form sugar from the para-galactan of *Lupinus hirsutus* was demonstrated by Schulze and Castoro (218). Ptyalin, pancreatin, malt diastase and "taka" diastase, will, however, in the course of 5 or 6 days' digestion at 35-40° C. render this carbohydrate soluble in water to the following extent:

	Per cent.		Per cent.
Malt diastase.....	38	Ptyalin	40
Taka diastase.....	35	Pancreatin.....	15

Grüss (184) has made exhaustive microchemical investigations upon the germinating date endosperm, in which he has been able to observe the solution of the galactans by enzymes developed during germination. Bourquelot and Hérissey (174) find a soluble enzyme hydrolyzing galactan,² produced by the germinating embryos of the seeds of the carob, *Nux vomica*, fenugrec and luzerne. Shellenberg (208), studying the action of moulds on hemicelluloses, found at least four different ferments showing considerable specificity in their action; seeds of *Lupinus hirsutus* (containing paragalactan) were attacked by most of these moulds (*Mucor neglectus*, *Mucor piriforme*, *Rhizopus nigricans*, *Thamnidium elegans*, *Penicillium glaucum*). Similarly, Hérissey (187) found galactose produced from manno-galactans by *Aspergillus niger* and *Aspergillus fuscus*; Saiki (205) obtained sugar from Irish moss by digesting it with inulase prepared from *Aspergillus niger* and *Penicillium glaucum*; and with "taka" diastase prepared from another mould, *Eurotium oryzae*.

Little is known of the action of bacteria upon galactans. Gran (182) found sugar produced from agar-agar by *Bacillus gelaticus*, through the action of an enzyme which he calls "gelase." Saiki (105),

¹Cf. Mannans, p. 283; for a further discussion of the occurrence of Galactans see v. Lippmann, *Chemie der Zuckerarten*, Vol. I, pp. 686-697.

²Cf. Mannans, p. 284.

in experiments with *B. coli communis*, on culture media containing different kinds of comminuted seaweed, found a slight gas production in one culture, in media with agar-agar and Irish moss.

GALACTANASES IN THE ANIMAL KINGDOM.

The only discovered instance of a galactanase in lower animals is cited by Bierry and Giaja (173), who found that the hepato-pancreatic juice of *Helix pomatia* produced galactose from extracts of carob seeds (*Ceratonia siliqua*); later experiments upon agar-agar, with extracts from a number of crustaceans (*Astacus fluviatilis* Rondel., *Homarus vulgaris* Bel., *Maja squinado* Rondel., *Carcinus moenas* L., and *Platycarcinus pagarus* L.) were entirely negative; the galactans of luzerne and fenugrec were attacked with difficulty by the extract from *Astacus*. Strauss (221) could find no enzyme attacking agar-agar, in the larvae and puppae of various species of *Lepidoptera* and *Diptera*.

No galactanases have been found in higher animals. Bierry and Giaja (173), using extracts of luzerne seeds, got negative results with digestive juices of dogs and rabbits, and Sawamura (207) obtained similar results with extracts of different sections of the alimentary canal of swine and horses. Saiki (205) found saliva, pancreatic, and intestinal juices unable to hydrolyze Irish moss.

DIGESTION AND UTILIZATION OF GALACTAN BY ANIMALS AND MAN.

The first study of the digestibility of galactans in higher animals was made in 1903, by Lindsey (191). Alsike clover-seed, containing 8 per cent galactan, was fed in connection with hay, the digestibility of which had been previously determined; from analyses of food and faeces, the galactan in the hay (1.72 per cent) was found to be 75 per cent digestible, and that in the clover 95.78 per cent digestible. Saiki (205) fed agar-agar and Irish moss to dogs and recovered a large part in the faeces, as shown by the increased amount of carbohydrate excreted. Lohrisch (194) fed dogs and rabbits agar-agar in its usual form, and also "soluble-agar" prepared from ordinary agar by Dr. Karl Dieterich of Dresden, Director of the Helfenberg Chemical Factory. This product seems to be partially hydrolyzed in its preparation, since it is not only readily soluble in water, but has slight reducing action; it yields on boiling with Fehling's solution, 3.5-4.1 per cent sugar, and if a watery solution is allowed to stand 18 hours at

37° C., it is further hydrolyzed and yields then 16.9–20.4 per cent sugar. The results of Lohrisch's experiments appear in the following table:

ANIMAL.	FOOD.	HEMICELLULOSE		HEMICELL-	HEMICELL-
		EQUIVALENT OF AGAR	FED.	ULOSE	ULOSE
				EXCRETED.	DIGESTED.
					<i>Per cent.</i>
Rabbit I.....	Ordinary agar	18.77 =	14.48	7.1	50.9
Rabbit II.....	Ordinary agar	11.8 =	9.11	4.71	48.3
Rabbit III.....	Soluble agar (given in 9 days)	95.9 =	65.02	14.2	78.1
Dog.....	Same as III	53.0 =	35.9	11.7	67.3

Lohrisch (194) has also studied the utilization of agar-agar in starving herbivora. In two experiments, rabbits starved for two days were fed ordinary agar as long as they would eat it, other animals of the same weight being kept in starvation as controls; in a third experiment, "soluble agar" was fed. Urine and faeces were collected and analyzed. Of the ordinary agar, about 50 per cent was excreted in the faeces; of "soluble agar," about 25 per cent. No positive evidence of any change in nitrogen excretion attributable to the agar fed, can be drawn from the protocols. One animal died through accident, another survived its control but one day, and the third, in spite of its apparently good digestion of the "soluble agar," died a week before its control.

In the case of rabbits made diabetic with phlorhizin and then fed 20-40 grams of both ordinary and soluble agar, Lohrisch (194) found that the D: N ratio remained fairly constant throughout each experiment, showing no marked increase in sugar excretion. We see, therefore, no grounds for assuming that agar-agar (*galactan*) forms glycogen in rabbits.

The first studies on the utilization of ga'actan by man were made by Saiki (205) (1906). In feeding experiments in which various carbohydrates were at different times added to a uniform diet, consisting of 513 grams beefsteak, 500-600 grams bread, 40 grams sugar, 31 grams butter, 2 eggs and 2 apples — a diet on which over 98 per cent of the carbohydrates were digested, he obtained the following results:

NO.	SUBSTANCE ADDED TO DIET.	EQUIVALENT OF SUBSTANCE IN DEXTROSE.	CARBOHYDRATES	
			IN FAECES CAL- CULATED AS DEXTROSE.	HEMICELLULOSE DIGESTED.
		<i>Grams.</i>	<i>Grams.</i>	<i>Per cent.</i>
1	20 grams agar.....	10	9.2	8
2	24 grams agar.....	12	8.8	27
3	40 grams wakame.....	4.7	3.4	28
4	45 grams kombu.....	11.4	2.5	78

Lohrisch has also studied the digestibility of "soluble agar" in man. Sometimes it is not well borne, especially if given in quantities over 50-60 grams per day and causes gas formation, diarrhoea, and other intestinal disturbances; in other cases, large amounts (100 grams per day) cause no unpleasant symptoms whatever. The agar was dissolved in some beverage, and the diet was otherwise carbohydrate-free. Some of the results are shown in the following table (194):

NO.	DURATION OF EXPERIMENT.	AMOUNT DIGESTED.		HEMICELLULOSE EXCRETED.	HEMICELL- ULOSE DIGESTED.	HEMICELL- ULOSE DIGESTED.
		As Air Dry Soluble Agar.	As Hemicel- lulose.			
		<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Grams.</i>	<i>Per cent.</i>
1	1 day	100	61.9	46.06	15.84	25.6
2	1 day	100	61.9	39.1	22.8	36.8
3	3 days	235	145.4	90.5	54.9	37.7
4	3 days	240	148.5	40.8	107.7	72.5
5	1 day	100	61.9	25.4	36.5	58.9
6	1 day	110	67.8	23.4	44.4	65.5

No. 4 was a case of chronic constipation; the high percentage of hemicellulose digested is in accordance with the observations of Lohrisch (193) and Pletnew (203), on the extraordinarily good utilization of all foodstuffs in chronic constipation. Two of these experiments were on diabetics, and showed that the 18.36 grams of "soluble agar" absorbed per day caused no increase of sugar in the urine, and had no noticeable effect on nitrogen metabolism.

From these experiments, we see that ordinary agar is digestible to a very small extent, and that even when changed to an easily hydrolyzed form, it is only digested to about 50 per cent. Is the part digested absorbed and utilized as galactose? The recent exhaustive

discussion of the behavior of galactose in the animal body by Brasch (175) renders any details on the utilization of this sugar unnecessary. Hofmeister (188) showed that of all sugars it is most readily excreted. That galactose can form glycogen in dogs and rabbits, has been shown by Weinland (226), Kausch and Socin (189), Cremer (177), Voit (223), Brasch (175), and others.¹ Brasch (175) has shown that the assimilation limits for galactose lie, for normal man, between 30 and 40 grams, while for dextrose they lie between 100 and 150 grams. Voit (224), Sandmeyer (206), Bauer (170), and others have shown that galactose, even in small amounts increases the sugar excretion in diabetes. It would seem, therefore, that if soluble agar were absorbed as sugar, it would increase the sugar output in the urine. To throw some light on this problem Lohrisch (194) has conducted three respiration experiments on men after ingestion of 100–110 grams of soluble agar, of which, on the average, about 63 per cent was absorbed. The changes in the respiratory quotient are shown in the following table:

Respiratory Quotient.

NUMBER OF HOURS AFTER INGESTION OF SOLUBLE AGAR.								
NO.	IN FASTING.							
		1	2	3	4	5	6	7
I	0.768		0.766	0.835	0.860	0.770	0.735	0.724
II	0.786	0.768		0.794	0.825	0.767		0.714
III	0.739			0.815	0.800	0.774		

NUMBER OF HOURS AFTER INGESTION OF SOLUBLE AGAR.							
NO.	IN FASTING.						
		8	9	10	11	12	13
I	0.768						
II	0.786		0.693	0.730		0.618	
III	0.739			0.703			0.669

The distinct rise in the respiratory quotient in the fourth hour (beginning in the third hour in Experiment I) would indicate that carbohydrate was being oxidized, which in this case must come from the agar. The low value in the later hours seems due to the oxidation of fatty acids;² that such acids may be formed from soluble agar by bacteria, appears probable also from the intestinal fermentation pro-

¹Cf. Magnus-Levy, Verwerthbarkeit der Galactose in normalen Organismus: *Openheimer's Handbuch der Biochemie der Menschen und der Tiere*, Vol. IV, p. 379.

²Cf. respiration experiments described under Cellulose.

duced when large amounts of this preparation are taken. A slight increase in acetone output, shown in the metabolism experiments with diabetics, points to the same conclusion. Perhaps, as Lohrisch suggests, the very slow digestion of the carbohydrate, may enable the organism to utilize the galactose formed, and account for its non-excretion, but this requires further demonstration.

According to these experiments by Lohrisch, cellulose and the soluble galactan show little difference in their physiological behavior. Both can be digested to about 50 per cent. Ordinary agar, as Saiki's experiments show, is largely recovered in the faeces; in fact, a therapeutic practice which has been recently established is based upon the recognized indigestibility of agar, namely, its employment as a remedy in cases of chronic constipation. It is especially valuable, as Mendel (196) points out, in those cases where the difficulty is due to an extremely complete digestion and absorption of all foodstuffs from the alimentary tract, which causes the formation of dry, hard faecal masses (*scyballa*) difficult to evacuate. The agar, remaining undigested and retaining a high percentage of water, gives bulk and softness to the faeces, and facilitates their daily elimination. Being resistant towards bacterial action, it causes neither gas formation nor production of harmful decomposition products. According to A. Schmidt (209), it can be advantageously taken in quantities up to 25 grams per day, part with the breakfast cereal, and part with sauce or cream, at another meal. In view of such facts as these, we are hardly prepared to agree with Lohrisch, that 'Cellulose and Hemicelluloses are readily digested.'

OCCURRENCE AND NATURE OF MANNANS.

As widely diversified in origin and character as the galactans, and very intimately associated with them are the Mannans. They show all possible degrees of solubility, from the readily soluble mucilage found in certain legumes, to the completely insoluble "reserve-cellulose," which forms the horny albumen in such seeds as the date, and which was long confused with true cellulose.

A few examples will serve to show the diverse places in which mannans may be found. They occur in yeast:¹ (258) in algae, as *Porphyra laciniata*; (278) in moulds, as *Penicillium glaucum*; (285) in the leaves and roots of the Japanese plant, *Conophallus konjaku* (280); in the bark and wood of many American trees (272).

¹For further discussion see v. Lippmann, *Chemie der Zuckerarten*, Vol. I, pp. 641-649, and Czapek, *Biochemie der Pflanzen*, pp. 325-329.

The most extensive study has been given to the mannans of various seeds, in which, as already shown,¹ mannans and galactans seem almost invariably to occur together. The seeds of the carob tree (*Ceratonia siliqua*) contain a hemicellulose originally called "caruban" by Effront (241) (1897), but shown by van Ekenstein (282) to yield mannose, and by Bourquelot and Hérissé (232) (1899), *d*-galactose. The first elaborate studies of "reserve-cellulose" were made by Reiss (264), who showed that the horny albumen of the seeds of *Phytelepas macrocarpa*, *Phoenix dactylifera* and other species of palm, *Allium cepa*, *Asparagus officinalis*, *Iris pseudacorus*, *Strychnos nux vomica* and *Coffea arabica*, differed chemically from true cellulose in their color reactions, in the ease with which they can be hydrolyzed, and in yielding, instead of dextrose, a sugar which he called "seminose," but which proved to be identical with Fischer and Hirschberger's (242) previously described mannose.

Mannan also occurs richly in the tubers of the many species of *Orchis* and *Eulophia* which are the source of commercial salep. On extraction with water, they yield a mucilaginous extract which was first studied by C. Schmidt (270) in 1844, and called by him "salep-bassorin"; on hydrolysis with dilute sulphuric acid he obtained, besides some gummy substance and cellulose, a fermentable sugar which he thought to be dextrose. Mulder (259) considered the salep mucilage a mixture of starch and gum or pectin acids, while Franck (243) thought it a modification of cellulose, and Girand (248) a transformation of a starchy substance into a variety of dextrin swelling in water. Pohl (263) by precipitation with neutral salts, distinguished an " α -Schleim" and a " β -Schleim." According to Thamm (276), who has made the most recent investigations, " α -Schleim" does not occur in German salep. Tollens and Gans (277) showed that on hydrolysis, besides dextrose, mannose or, as they called it, "isomanitose" was formed, but this was shown by Fischer and Hirschberger (242) to be identical with *d*-mannose. Thamm (276) and Hilger (254) have shown conclusively, that the starch-free water extract contains an anhydride of mannose only.

A very resistant type of mannan occurring in some plants, has been designated as manno-cellulose by Schulze (273). Bertrand (227) finds it taking the place of xylan in the woody tissues of gymnosperms.

¹Cf. Schulze and his coworkers, and Goret, under Galactans. Also Schulze and Godet, *Zeitschrift für physiologische Chemie*, V. 61, p. 279, for a very complete review.

MANNANASES IN THE VEGETABLE KINGDOM.

There is very little literature concerning the action of bacteria upon mannans. Sawamura (267) observed that extracts of *Hydrangea paniculata*, used in the manufacture of Japanese paper, which contain mannan (along with galactan and araban), became liquefied on standing. In bacteriological studies with extracts of this plant, and of roots of *Conophallus konjaku*, he found that only *B. mesentericus vulgaris* dissolved these mannans. The action was greatly facilitated, and sugar formation increased if a certain wild yeast, in itself inactive, were present. Traces of a similar enzyme seem to occur in *B. prodigiosus*.

In his studies of the action of moulds on hemicelluloses, Schellenberg (269) found that the seeds of *Ruscus aculeata*, which yield almost exclusively mannose (237-240), were attacked only by *Penicillium glaucum*. Hérissé (253), using pure cultures and water extracts of cultures of *Aspergillus niger* (grown on media rich in mannose and galactose to incite the development of mannanase and galactanase), with suitable antiseptics and controls, obtained mannose — and galactose — from seeds of *Cerantonia siliqua* and *Gleditschia triacanthus*, and an abundant yield of mannose from salep; similar results were obtained with *Aspergillus fuscus*.

As early as 1862, Sachs (266) observed the change of the thickened cell-walls of the date endosperm into sugar during germination. The cytases producing this change in 'reserve-cellulose' were later carefully investigated by Reiss (264), Brown and Morris (230), Newcombe (261), Grüss (251), and others. Still more recently, Bourquelot and Hérissé have made many studies on the specific characteristics of these plant enzymes. An exhaustive review of the literature on mannans and the action of enzymes upon them has been published by Hérissé (253), consequently this subject will only be reviewed very briefly here.

Grüss (251) has demonstrated that the solution of the date embryo (*Phoenix dactylifera*) is due to a ferment, the product of whose activity is galactan and mannose. Efront (241) (in 1897) attributed the solution of the albumen of carob seeds (called by him caruban) to a "caroubinase," but thought that the product of its activity was not identical with the products of hydrolysis; in 1899, however, Bourquelot and Hérissé (233) showed the possibility of obtaining mannose by the action of a soluble ferment derived from these seeds, which they called "seminase." Shortly afterwards, a similar enzyme was

isolated by them from the seeds of *Phoenix canariensis*. Hérissé (253) has been able to show that seeds of such legumes as luzerne, fenugrec, and common genet have, at least at the time of germination, ferments capable of transforming mannans—and galactans—into their corresponding sugars. Experiments *in vitro* show that they are not limited to action upon the seeds by whose embryos they are produced, but act on the reserve-cellulose of seeds from very distinct groups of plants. However, the luzerne ferment does not digest all mannans and galactans; it will hydrolyze the mannans of the tubers of the Orchis family (and commercial salep prepared from them), but not those of the albumen of palm seeds.

Grüss (251) has also shown that the enzyme of the date endosperm hydrolyzes starch, although this does not occur in the date seed, and that malt diastase works on α -mannan (the soluble mannan of date seeds, according to Grüss) which does not occur in the barley endosperm. Grüss considers diastatic enzymes a group working not only on starch, but also on hemicelluloses. Hérissé thinks that diastase and seminase are found together in varying proportions in barley, legumes, carob seeds, etc., and that neither is a simple ferment, but a "superposition de ferments," and defines "seminase" as a "ferment or group of soluble ferments, causing the transformation of the carbohydrates of horny albumens of the seeds of *Leguminosae* into assimilable sugars." Gatin (247) has made further researches upon the nature of seminase, and states that during the germination of certain seeds whose reserve is in the form of mannan, the presence of mannose is exceptional, but dextrose occurs in abundance. This phenomenon he attributes to a "manno-isomerase," which transforms the mannose, as fast as formed by the seminase, into dextrose. Experiments *in vitro* seem to indicate that this is a soluble ferment.

MANNANASES IN THE ANIMAL KINGDOM.

There are only a few instances on record of mannases occurring in lower animals. Bierry and Giaja (228, 229) found that the hepatopancreatic juice of *Helix pomatia* was capable of producing mannose from extracts of carob seeds and salep; that of *Astacus fluviatilis*, *Homarus vulgaris*, and *Maja squinado*, from the ivory nut (*Phytolepas macrocarpa*), the two latter hydrolyzing it at ordinary room temperature. On the other hand, the mannans of fenugrec and luzerne were hydrolyzed with difficulty, or not at all, by very pure gastro-intestinal juice. No mannanase was found by Strauss (275) in the larvae and

pupae of *Lepidoptera* and *Diptera*. Similar negative results have been obtained with the digestive enzymes of higher animals. Kinoshita (257) found that emulsin and invertin did not hydrolyze the mannans of *Conophallus konjaku* and Gatin (245, 246) tried the blood of rabbits, chicken serum, the pancreatic juice of dogs, the macerated intestines and pancreas of chickens and cattle, upon salep and carob seeds with negative results; on the other hand, Sawamura (268) reports a mannanase in the extracts from different sections of the alimentary tract of swine and horses.

DIGESTION AND UTILIZATION BY ANIMALS AND MAN.

There are also very few records in the literature of feeding experiments with mannans. In a paper in the *Zeitschrift für Biologie*, Voit (283) in 1874¹ described one by Hauber, who fed a medium sized dog 390 grams of dry salep powder in the course of eight days. The faeces of the feeding period were roughly marked off, and Hauber reported no unchanged salep present in them, because there was no swelling in water as with the original powder. Calculations based on the yield of sugar from the faeces on hydrolysis showed that at least 50 per cent of the salep was absorbed. This seems to have been a very crude experiment, and cannot be considered of convincing value.

In 1879, Weiske (284) fed carob-beans (*Ceratonia siliqua*) to sheep, along with meadow hay, and compared the nutritive value of this ration with one in which the carob-beans (210 grams) were replaced by an equivalent weight of starch, sugar and protein (from crushed peas). The coefficients of digestibility and nitrogen balance were so nearly the same on the two rations, that Weiske pronounced "Johannisbrod" (carob beans) an acceptable and digestible feed for sheep.

In 1890, Schuster and Liebscher (274) tried feeding the sawdust of ivory nut (*Phytalepas macrocarpa*) to sheep, having previously found that it had a favorable effect on cattle. Merino sheep gained considerable fat when fed oat straw and vetch fodder, plus ivory nut sawdust furnishing 50 per cent of the digestible carbohydrates. The ration, exclusive of the ivory nut, did not yield enough energy for such a result to be possible, hence the latter must have been utilized. The coefficient of digestibility, both for the nitrogen-free extract and crude fiber of this material, was at the same time shown by Niebling (262) to be 82 per cent for sheep.

¹This paper reviews the early literature on gums.

From these experiments, mannan would seem to be well utilized by herbivora. The only experimental data regarding the nutritive value of mannans to man, are cited by Oshima (15) from work by Kano and Iishima (255), who found the coefficient of digestibility of konjaku 82 per cent (prepared from *Conophallus konjaku*). Further investigations seem highly desirable, in view of the fact that in certain regions food stuffs like salep and konjaku, consisting of almost pure mannan, are among the chief articles of the poor man's diet. It is also a question whether the nutritive value of bark, especially of coniferous trees, is due to mannan present. According to Dillingham (239) the quantity of mannan present does not justify such an assumption, aside from the question of its digestibility.

We have finally to inquire whether mannan can be hydrolyzed within the organism, and if so, whether the mannose produced can be retained and form glycogen. From the literature on the subject, it appears that mannose is well utilized by rabbits, dogs and men. According to Neuberg and Mayer (260), the *d*-form is better utilized than the *l*- or *i*-form. Mannose is readily converted to dextrose in the organism; thus Neuberg and Mayer found that a rabbit, receiving 10 grams of *l*-mannose *per os*, excreted 1 gram *l*-mannose and 4-5 grams *l*-glucose; 10 grams of *d*-mannose given rabbits *per os*, or subcutaneously, were almost completely oxidized. Rabbits fed 30 grams *d*-mannose by Cremer (238) excreted 3-4 grams in the urine, and dogs given 20 grams by Rosenfeld (265), excreted over 4 grams. This is somewhat more than would be excreted on giving equally large quantities of dextrose or levulose. Cremer (238) found no sugar in the urine of a man after feeding 3-12 grams of mannose.

That mannose can act as a glycogen former in rabbits, has been demonstrated by Cremer (238) and also by Rosenfeld (265). Neuberg and Mayer (260) found only a small amount of glycogen in the livers of starving rabbits after feeding *l*-mannose, but even this form is utilized to some extent. There is good reason for assuming, therefore, that if mannans can be converted into mannose in the process of digestion, they may be considered as true nutrients for the organism, the mannose being to a high degree capable of absorption and conversion into glycogen.

OCCURRENCE AND NATURE OF LEVULANS.

A number of polysaccharide carbohydrates yielding levulose on inversion have been described. They are all levo-rotatory, more or less soluble in cold water and insoluble in alcohol, and easily hydrolyzed by dilute acid, but have not been investigated sufficiently to permit any conclusion to be drawn respecting their relation to one another. The most important of these substances and their sources are shown in the following table:*

NAME.	SOURCE.	INVESTIGATOR.
Inulin	Tubers of dahlia, artichoke, Jerusalem artichoke, elecampane; bulbs of onion, garlic, narcissus, hyacinth, and tuberose; flowers, seed, etc., of various compositae	Tanret (321) Chevastelon (291)
Pseudo-inulin Inulenin Helianthin Synanthrin	Tubers of dahlia, artichoke, Jerusalem artichoke, elecampane; bulbs of onion, garlic, narcissus, hyacinth, and tuberose; flowers, seed, etc., of various compositae	Tanret (321, 322)
Levulin	Tubers of <i>Helianthus tuberosus</i> (Jerusalem artichoke)	Reidemeister (314) and others
Phlein	Rootstalks of <i>Phleum praetense</i> (Timothy)	Ekstrand and Johanson (296)
Cerosin	Unripe grains	Tanret (320)
Graminin	Rootstalks of various grasses, e.g., <i>Trisetum alpestre</i>	Ekstrand and Johanson (296) Harlay (301)
Triticin	<i>Dracaena australis</i> and <i>rubra</i> , <i>Triticum repens</i> (couch grass)	Reidemeister (314)
Sinistrin	Bulbs of <i>Scilla Maritima</i> (Sea onions or squills)	Schmiedeberg (318) Reidemeister (314)
Levulan	Molasses in beet-sugar industry	v. Lippmann (309)

* Cf. v. Lippmann, *Chemie der Zuckerarten*, Vol. I, pp. 795-807.

The best known member of this group is inulin,¹ closely associated with which are the four levulans described by Tanret; these seem to be intermediate products between inulin and levulose, all having greater solubility than inulin, but less levo-rotatory power. The other carbohydrates mentioned are also more soluble than inulin, but have higher specific rotation.

LEVULANASES IN THE VEGETABLE KINGDOM.

Comparatively few studies have been made upon the action of enzymes on the levulans, and these have been for the most part limited to inulin. Certain micro-organisms as *B. Coli communis* (295), *Clostridium pastorianum* (328), and several Schizomycetes, decompose inulin, but without any production of sugar. Yeast, according to Tanret (321) does not ordinarily ferment it, but Lindner (308) asserts that certain forms of top yeast change it readily. Levulin is fermented by yeast, according to Lévy (307), and triticin, in the course of four or five days, according to Reidmeister (314); but it seems probable that the first changes are due to gradual hydrolysis on standing in water, or to other organisms.

The effect of vegetable enzymes on these carbohydrates, as far as they have been studied, is shown in the following table:

NAME OF LEVULAN.	INVERTIN OF YEAST.	MALT DIASTASE.	"TAEA" DIASTASE.	INULASE OF ASPERGILLUS.
Inulin	- (8)	- (3)	- (3)	+ (7)
Levulin	+ (1)			
Graminin		- (4)		+ very slowly (4)
Triticin	- (2)	+ (5)		
Sinistrin		- (6)		

(1) Levy (307)

(2) Reidmeister (314)

(3) Chittenden (292)

(4) Harlay (301)

(5) Reidmeister (314)

(6) Schmiedeberg (318)

(7) Dean (293) and others

(8) Komanos (303)

Discovery of the best known ferment for any levulan is due to Green (300) who, in 1888, extracted such an enzyme from the tubers of the Jerusalem artichoke (*Helianthus tuberosus*), and named it "in-

¹For description and early literature see Kiliani (302) and Dean (294).

ulase." Subsequently, Bourquelot (289) found inulase in *Aspergillus niger* and *Penicillium glaucum*; and Chevastelon (291) showed that this enzyme would hydrolyze the inulin of the monoctyledons. Deán (293) has studied the properties of inulase exhaustively, and shown that in *Aspergillus* and *Penicillium* it exists only as an endoenzyme. Went (327) has found inulase also in *Monilia sitophila* and other *Amylomyces*.

LEVULANASES IN ANIMALS.

The first instance of an inulase in an animal organism has been cited by Strauss (319). In 1908, he reported studies on the enzymes of seven species of *Lepidoptera* and *Diptera*, during their various stages of development (*Euproctis chrysorrhea*, *Ocneria disparata*, *Bombyneustria*, *Bombyx mori*, *Galleria melonella*, *Hyponomenta*, *Calliophera vomitoria*), but found inulase present only in the eating larvae of *Bombyx mori* and *Hyponomenta*. No inulase was present in the larvae of these species after they had ceased eating, nor in the pupae and imagines.

The results of Kobert (304) in 1903, with extracts of May beetles, cross spiders, scorpions, cockroaches, ascarides, pupae of pine spiders, and house flies, were entirely negative; so also have been the experiments *in vitro* with digestive juices of higher animals, as shown by table on following page.

DIGESTION AND UTILIZATION BY ANIMALS.

Inulin is hydrolyzed by very dilute acid (0.05–0.2 per cent at 40° C. according to Chittenden), so that its more or less complete inversion by the gastric juice is possible, and has led many to believe that in spite of the negative results obtained with amylolytic enzymes shown above, it might be converted into levulose, and as such be readily utilized by the animal organism. It has therefore frequently been recommended for the diet of diabetics, who show a special tolerance for levulose; in fact, simply because inulin did not reappear in the urine as sugar, when fed to diabetics, its utilization has been assumed by many, no account being taken of its possible reappearance in the faeces. This reappearance is well demonstrated in an experiment of Sandmeyer (317) in which, after feeding 80 grams of inulin to a diabetic dog, over 46 grams were recovered in the faeces.

AUTHORITY.	DATE.	SOURCE OF ENZYME.	KIND OF LEVULAN.	RESULT.
Komanos (303)	1875	Saliva	Inulin	—
		Pancreatic juice	Inulin	—
Schmiedeberg (318)	1879	Saliva	Sinistrin	—
Chittenden (292)	1898	Saliva	Inulin	—
		Pancreatic juice	Inulin	—
Bierry and Portier (288)	1900	Macerated pancreas and intestines of dog, rabbit and seal	Inulin	—
Bierry and Portier (288)	1900	Macerated pancreas and intestines of dogs, rabbits; fed three months on artichokes to induce formation of an inulase*	Inulin	—
Harlay (301)	1901	Saliva	Graminin	—
Bierry (286)	1905	Pancreatic juice of dog	Inulin	—
		Pancreatic juice of dog + macerated intestines of dogs and rabbits	Inulin	—
Bierry (287)	1910	Pancreatic juice of dog from pancreatic fistula after injection of secretin	Inulin	—
		Same pancreatic juice added to macerated intestines of dog and rabbit, in slightly acid, slightly alkaline and neutral solutions	Inulin	—
		Hepato-pancreatic juice of <i>Helix pomatia</i>	Inulin	Levulose
		Enzyme prepared from hepato-pancreatic juice of <i>Helix pomatia</i>	Inulin	Levulose
Weinland (326)	1905	Extract of small intestine of dog	Inulin	—

* Cf. Riehaud, (326).

Attempts to induce glycogen formation in rabbits have not justified the hopes of the dieto-therapists in regard to inulin as a food for diabetics. The earlier experiments were either negative or open to criticism on account of faulty technique. The more discriminating work of recent investigators (Miura [313]; and Mendel and Nakaseko [312]), has shown that little glycogen is formed from inulin, even under the most favorable circumstances. A brief survey of the experiments in this field is given in the following table:

NAME OF INVESTIGATOR.	DATE.	NUMBER OF EXPERIMENT.	AMOUNT INULIN INJECTED.	AMOUNT OF GLYCOGEN FORMED IN LIVER.	REMARKS.
Luchsinger (310)	1874	1	40 gms. in 6 injections	Grams. 0.53	Estimated on basis of glycogen $[\alpha]_D = 130$ degrees, hence figure is too high
Komanos (303)	1875	1	20 gms.	0.835	Strikingly less than in Fructose feeding
Külz (305)	1875	5	40 gms. in 5 injections	1. 0.475 2. 0.280 3. 0.724	
				4. 0.204 5. 0.362	
Frerichs (299)	1876	3	1. 50 gms. in 5 injections 2. 50 gms. in 3 injections 3. 50 gms. in 3 injections	0.1241 } 0.828 } 0.1395 }	Unaltered inulin found in faeces
von Mering (324)	1877				Says results verify those of earlier experimenters, hence no figures given
Finn (297)	1877	7	25-35 gms.	Trace in 5 exp. 0.124 in 1 exp. 0.196 in 1 exp.	
Miura (313)	1895	19	10-25 gms, 10-12 injections in $\frac{1}{2}$ - to 1-hour periods	Total glycogen content of livers: 0.123- 3.1468	In all cases examined large amounts inulin and levulose in the alimentary tract
Mendel and Nakaseko (312)	1900	7	18-33 gms. in doses of 2.8 gms.	0.0223 0.0518 0.2049 0.4066 0.5087 0.7555 0.2411	Estimating the starvation maximum for rabbits, starved $5\frac{1}{2}$ -7 days, as 0.252 g. per kilo, in only 3 cases did the glycogen content exceed the limit

Excluding the experiment of Luchsinger (310) which was estimated on a very low specific rotation for glycogen, only four out of the 17 experiments before Miura's (313) are positive, and in these the glycogen was estimated without purification, so that the figures are probably high. In more reliable experiments of Miura (313), and Mendel and Nakaseko (312), the glycogen content of the rabbits' livers was as low or lower than the starvation maximum for the rabbit, as estimated by Külz (309), so that glycogen formation from inulin must be regarded as doubtful, or very slight.

When inulin is introduced parenterally into the organism, there is no inversion or utilization, as shown by the experiments of Mendel and Mitchell (311). They injected warm solutions into the peritoneal cavity, and determining the output of inulin in the urine (which was sugar-free) by calculations from the specific rotation, recovered 2.2 grams of 2.8 grams injected. In an experiment in which the sugar-free urine was hydrolyzed, and the output of inulin calculated from the amount of reducing sugar obtained, 1.43 grams were recovered out of 2.2 grams injected. Weinland (326) after subcutaneous injections of inulin into dogs, continued for a month, found no inulase produced thereby. On the other hand, Saiki (316) succeeded in producing a definite anti-inulase in rabbit's serum.

We see, therefore, that inulin is not attacked by animal enzymes, as far as investigated, with the possible exception of two species of invertebrates; and by a very few vegetable enzymes. It appears to a considerable extent in the faeces after being fed *per os* in spite of the ability of the gastric juice to hydrolyze it. In spite of the accepted fact that levulose is capable of being directly utilized by the animal body there is no conclusive evidence of glycogen formation from inulin. Whether other levulans resemble this hemicellulose in these respects has not been investigated.

OCURRENCE AND NATURE OF DEXTRANS.

In the higher plants, starch, dextrin, and cellulose occur almost to the exclusion of other anhydrides of dextrose. A few hemicelluloses yielding dextrose have been described, however, such as " α -amylam" (soluble in hot water) and " β -amylam" (soluble in cold water), discovered by O'Sullivan (343) in wheat, rye and barley; those in the mucilaginous extracts of flax-seed and fleabane, described by Bauer (329) and Rothenfusser (345); and that in *Colocasia antiquorum*, described by Yoshimure (352).

Even in the lower plants, dextrans do not occur to any great extent. They have been observed in bacteria (338), yeast (339), fungi (350), and liverworts (337), but occur most abundantly in lichens and algae¹ the lichens, as already stated, yielding dextrans to which the names lichenin, isolichenin, usnin, everniin, etc., have been given. Especial interest is attached to the dextrans of *Cetraria islandica* (lichenin and isolichenin) which together form 80-90 per cent of the total carbohydrates of this lichen, because of its abundance in northern lands and its use there as a foodstuff; hence these carbohydrates have received more attention from chemical investigators than any other dextrans. Ever since Berzelius (333), in 1808, studied the hot water extract of *Cetraria islandica*, and called the carbohydrate mixture so extracted "moss-starch," on account of its giving a blue color with iodine, the idea that it is, like starch, a valuable nutrient, has prevailed. That this hot water extract contained two carbohydrates, one soluble in cold water (isolichenin) and the other in hot, was demonstrated by Berg (332) in 1873, who also showed that the blue coloration with iodine was a property of isolichenin, but not of lichenin. Lichenin was first found to yield dextrose by Klason, in 1886 (337). The next year the two carbohydrates were more fully investigated by Höinig and St. Schubert (336), who have carefully reviewed the earlier literature on this subject. That lichenin and isolichenin yield dextrose on hydrolysis, has been verified by Karl Müller (341), Brown (334), and Ulander (348), who have also shown the hemicelluloses of the water-insoluble part to consist of dextran, mannan, and galactan, with a small amount of pentosan. Escombe's (335) observation that lichenin yields galactose has proved to be incorrect.

DEXTRANASES IN THE VEGETABLE KINGDOM.

Höinig and St. Schubert (336) subjected isolichenin to the action of malt diastase, and observed a rapid disappearance of the iodine color reaction, and the formation of a dextrin-like substance precipitable by alcohol — a result verified by Brown (334) in 1898. Berg (332) treated lichenin with malt diastase but was unable to observe any change produced in it; his results also have been verified by Brown (334). The only experiments in which sugar has been obtained from lichenin by the action of vegetable enzymes have been carried out by Saiki (346) with "Taka" diastase from *Eurotium oryzae* and inulase from *Aspergillus niger*.

¹Cf. p. 255, also v. Lippmann, *Chemie der Zuckerarten*, Vol. I, pp. 215-220.

DEXTRANASES IN THE ANIMAL KINGDOM.

Attempts to hydrolyze lichenin by animal enzymes have been uniformly unsuccessful. The most exhaustive researches were made by Nilson (342), in 1893, partly with pure lichenin and partly with the powdered lichen itself. Digestions were made with human gastric juice for 24 hours, in neutral, acid, and alkaline solutions; with pancreatic extracts; with gastric juice followed by pancreatic extract; and with these same extracts, using preparations treated with $\frac{1}{4}$ per cent sodium hydroxide solution for 24 hours before the digestion. Nilson significantly remarks that this resistance to sugar-forming enzymes is worthy of note, inasmuch as certain lichens have been considered valuable food for man, and that it is hard to understand how reindeer utilize the carbohydrates of lichens. His negative results with animal enzymes have been substantiated by Brown (334)—who found digestion with 0.2 per cent to 0.4 per cent hydrochloric acid equally ineffective — and by Saiki (346). Torup (347) reports that the dextran isolated from *Laminaria digitata* by Krefling is not hydrolyzed by ptyalin, amylopsin or diastase.

DIGESTION AND UTILIZATION IN ANIMALS AND MAN.

Interest in the digestibility of lichenin arises, not only from its use in the diet of normal individuals, but in the possibility of its furnishing a substitute for other carbohydrates in the diet of diabetics. After this idea was set forth by Kütz (305), in 1874, it is not surprising to find, in 1879, the Italian physician Cantani,¹ and the Norwegian physician Bugge² reporting experiments in the use of Cetraria bread for diabetics. Without any further observations than that the sugar in the urine was not increased, the idea prevailed which Voit expressed in his monograph on Nutrition in 1881 (348) and Poulsson repeated in 1906 (344), that in some way or other, the "moss-starch," or lichenin, was changed into sugar in the alimentary tract, and served as a true nutrient. Poulsson undertook to verify this by feeding experiments with two diabetics, but as Mendel (340) has taken pains to point out, the results obtained, namely that 45-49 per cent of the carbohydrates of the Cetraria bread eaten were utilized, are unreliable, since the carbohydrates of the faeces were calculated by difference, instead of being determined directly by analysis.

¹Cited by Poulsson (344).

²Bugge, *Förhandlingar i det medicinske selskap, Kristiania, 1879, p. 179* (cited by Poulsson).

The few feeding experiments made with animals do not sustain the claims made for the value of Cetraria as a foodstuff. Brown (334) found only 1.25-0.7 per cent glycogen in the livers of rabbits after Cetraria feeding, but these results are not very satisfactory, since the rabbits would not eat it very well. An old experiment by von Mering (351), in which 16 grams lichenin were fed to each of two rabbits, shows 0.56-0.63 grams of glycogen in the liver, but Miura (313) has pointed out that his glycogen estimates were probably too high. Saiki (346) fed Cetraria extract, containing 2 per cent dry matter, in portions of 292 cc. and 300 cc. on two successive days, to a meat-fed dog. The faeces of the feeding period were marked off at the beginning of the Cetraria diet by fine quartz, and at the end by cork. Their composition is shown in the following table:

DIET		WEIGHT AIR DRY, GRAMS.	CARBOHYDRATE.	AS DEXTROSE.
Meat.....	2 days	10	5.8	0.68
Meat + Cetraria extract..	2 days	15*	25.8	3.90
Meat.....	2 days	5*	24.5	1.20
Meat.....	2 days	6	3.2	0.19

* Faeces of Cetraria Period.

The Cetraria extract contained 6.3 grams carbohydrate estimated as dextrose, the faeces 5.1 grams.

Feeding experiments on man, in which the intake and output of carbohydrate have been carefully determined by direct analysis of the carbohydrate as dextrose, have recently been conducted in Professor Mendel's laboratory. The data have not yet been published in detail, but from a preliminary description given by Mendel (340) is taken the following report of one experiment*:

	FAECES.		CARBOHYDRATE.		CETRARIA FED.
	Weight Air Dry.		As Dextrose.		
	Grams.	Grams.	Per cent.		
I. Fore period = 3 days.....	35	2.1	1		
Cetraria period = 3 days.....	146	38.0	56		80 g. = 56g. as dextrose
II. Fore period = 2 days.....	68	6	4		
Fore period = daily.....	34	6	2		
Cetraria period = 1 day.....	53	24	13		20 g. = 14½ g. as dextrose
After period = 2 days.....	29	6	2		

* From unpublished experiments by Dr. V. C. Meyers, Sheffield Laboratory of Physiological Chemistry.

In this experiment, the *Cetraria islandica* was carefully washed, extracted with a dilute solution of potassium carbonate, to remove the bitter principle; again thoroughly washed, dried and ground to a powder. This preparation contained 72.5 per cent carbohydrate as dextrose. The carbohydrates of the diet, throughout the experiment, were limited to fine white bread and zwieback, forms in which they are utilized in man to 98 per cent. The faeces were hydrolized with dilute acid, and the carbohydrates determined as dextrose by Allihn's gravimetric method. It is evident that nearly all of the *Cetraria* carbohydrate escaped digestion and was recovered in the faeces.

Through the kindness of Professor Mendel, the protocol of a similar experiment, by Mr. S. W. MacArthur, is also reproduced, in which the technique was practically the same as described for Dr. Myers's experiment.

PERIODS.	DIET.	COMPOSITION OF THE FAECES.			
	Cellulose-Free.	Weight Moist.	Weight Air Dried.	Dextrose.	Dextrose.
		Grams.	Grams.	Per cent.	Grams.
Fore = 3 days....	Meat, etc.	281	90.0	4.4	3.96
Mid = 3 days....	Meat + <i>Cetraria</i> *	542	149.0	27.6	34.5*
After = 3 days....	Meat, etc.	284	87.5	4.9	4.2

* Amount *Cetraria* eaten = 47 grams, which would be equivalent to 34.1 grams of dextrose in faeces.

It is evident that the results of this experiment simply confirm those of Dr. Myers, and demonstrate that uncooked *Cetraria*, although taken in a form as favorable as possible for its digestion, is scarcely affected by its passage through the alimentary canal, and must be classed among the indigestible carbohydrates. Very desirable experiments on the digestibility of the peculiar carbohydrate of *Cetraria* — lichenin — are also being conducted, which may throw new light on the digestibility of the dextrans, but at present we certainly have no grounds for assuming that this group of hemicelluloses deserves to be classed with the true nutrients; all experiments show that they are not attacked by animal enzymes, and are recovered unchanged in the faeces after feeding.

In conclusion, attention may be called to certain data from Japanese dietary studies, given by Oshima (15), as to the digestibility of

some dried marine algae, which have not been mentioned in connection with the different classes of hemicelluloses. The coefficient of digestibility for each species studied is given in the following table:

ALGAE DRIED.	OTHER SUBSTANCES IN DIET.	COEFFICIENT OF DIGESTIBILITY (Carbohydrates including crude fiber).
Ecklonia bicyclis.....	Shoyu* and sugar	36.2
Laminaria sp.....	Shoyu	75.2
Laminaria sp.....	Shoyu and cleaned rice	55.0
Ulopteryx pinnatifida.....	Cleaned rice, shoyu, sugar	72.3
Average.....		67.7

* Soy-bean sauce.

III. EXPERIMENTAL PART.

INTRODUCTION.

The foregoing review has emphasized the limits of our knowledge, both in regard to the chemical composition of marine algae, and their fate in the alimentary tract of men and animals, as determined by actual measurement of intake and output, and as explained by the action of bacteria and enzymes *in vitro*. Ten species of marine algae have, therefore, been made the basis of the present investigations. Eight of them were Hawaiian Limu, obtained, as already stated, through the kindness of Miss Minnie Reed, Science teacher in the Kamehameha Boys' School, Honolulu. They were dried in the sun, with the salt water adhering to them, before shipping to America. The other two (dulse and Irish moss) were easily obtained in our Eastern markets.

That the carbohydrates of algae are chiefly hemicelluloses, is indicated by the analyses which have already been made; that in many species, these are to a great extent water-soluble, is also well known. In as much as such soluble forms are thus particularly well adapted for nutrition investigation on account of their freedom from all incrusting substances, which end to interfere with digestion, the present studies have been confined as far as possible to them. Since it was desirable to study the different groups of hemicelluloses, and mannans and levulans were not found in the seaweeds in sufficient quantities for metabolism experiments, these were obtained from other sources; a mannan from salep, and a levulan (sinistrin) from squills (*Scilla maritima*).

Other investigators in this laboratory are working on a dextran which would naturally be included here, namely lichenin from *Cetraria islandica*; consequently no experimental studies on this group of hemicelluloses have been made. In considering any classifications of these materials, it must be borne in mind that most of these carbohydrates are more or less complex in nature, and can be grouped only with reference to what appears to be the chief constituent in any given case. The following list comprises all the species examined, arranged upon this plan:

I. THE PENTOSANS:

- Dulse (*Rhydomenia palmata*),
- Limu Lipoa (*Haliseris pardalis*),
- Limu Eleele (*Enteromorpha intestinalis*),
- Limu Pahapaha (*Ulva lactuca laciniata* and *Ulva fasciata*).

II. THE GALACTANS:

- Irish Moss (*Chondrus crispus*),
- Limu Manauea (*Gracilaria coronopifolia*),
- Limu Huna (*Hypnea nidifica*),
- Limu Akiaki (*Ahnfeldtia concinna*),
- Limu Uaualoli (*Gymnogongrus vermicularis americana* and *Gymnogongrus disciplinalis*),
- Limu Kohu (*Asparagopsis sanfordiana*),
- Slippery Elm (*Ulmus fulva*).

III. THE MANNANS:

- Salep (Species of *Orchis* and *Eulophia*).

IV. THE LEVULANS:

- Sinistrin (*Urginea* or *Scilla maritima*).

The primary object of these investigations has been to determine the fate of these substances in the alimentary canal of man, since they are all used as foodstuffs except sinistrin, and are all representative of a large class of materials so employed. The experiments conducted have been CHEMICAL, BACTERIOLOGICAL and PHYSIOLOGICAL in character, and each of these phases will be taken up separately in turn in the following pages.

CHEMICAL INVESTIGATIONS.

The aim of the experiments was to isolate, identify, and prepare for bacteriological and physiological experiments, any water-soluble carbohydrates present in sufficient amount in the materials under consideration; and to determine such of their properties as would facilitate their detection, isolation, and quantitative estimation in these experiments.

GENERAL METHODS.

All the seaweeds, with the exception of Irish moss, were washed repeatedly in cold tap water, to remove salt, sand, and other foreign substances, and for convenience, dried by spreading in thin layers

over steam radiators. The Irish moss, being comparatively free from salt, etc., and largely soluble in pure water, was quickly washed once, and extracted immediately.

All hydrolyses of carbohydrates were made with 2 per cent hydrochloric acid, by boiling with a reflux condenser over a free flame. After cooling, the acid was neutralized with potassium hydroxide, using phenolphthalein as an indicator, when the solutions were sufficiently light in color; in other cases, litmus paper was employed. When the products of hydrolysis served to determine the nature of the carbohydrates, they were evaporated on a water bath nearly to dryness, the residues extracted with hot 95 per cent alcohol the alcohol removed from the filtered solution by evaporation, the residues frequently taken up in a little water and decolorized with charcoal, concentrated, and again extracted with absolute alcohol.

All qualitative tests for reducing sugar were made with Fehling's solution; all quantitative tests by Allihn's gravimetric method for dextrose, the results being calculated as dextrose in view of the complex nature of most of the products, and the advantage of uniformity. On all preparations used for feeding experiments, the length of time in which the maximum yield of sugar could be obtained has been determined, as a criterion in analyses of faeces. Five grams of dry air material were hydrolyzed in 500 cc. of 2 per cent hydrochloric acid, 50 cc. being removed at intervals of one or more hours, cooled, neutralized, made up to 100 cc. and reducing power determined as dextrose by Allihn's gravimetric method.

Tests for the presence of fermenting sugars have been made in fermentation tubes with fresh compressed yeast, using as controls solutions of the substance to be tested, without yeast, and dextrose solutions with yeast.

All carbohydrate solutions for polariscopic examination have been clarified by addition of an equal volume of alumina cream.

Qualitative tests for pentosans have been made by boiling the substance to be tested in a small Erlenmyer flask with 12 per cent hydrochloric acid and testing for furfurol with anilin-acetate paper.

Quantitative tests for pentosans have been made by the furfurol-phloroglucin method.¹

Tests for galactans or galactose have been made by oxidation with nitric acid to mucic acid, and the mucic acid identified by its melting point (212° C.-215° C.).

¹Described in "Official and Provisional Methods of Analysis," United States Department of Agriculture, Bureau of Chemistry, Bull. No. 107, 1907.

Qualitative tests for mannose have been made by Storer's (271) method. The products of hydrolysis, freed from the greater part of the salts, gums, etc., in the manner already described, were taken up in a little water, and portions of 1 cc. or 2 cc. placed in test tubes. The reagent for testing was freshly prepared by shaking together 1 cc. of phenylhydrazin, 2 cc. of glacial acetic acid, and 10 cc. of distilled water. 3-16 drops of this reagent were added to each of the test tubes, and after standing several hours at room temperature, they were examined for precipitates of mannose-hydrazone. These precipitates were examined under the microscope, because they usually contained considerable amorphous matter. The mannose-hydrazone itself does not come down as colorless rhombic plates at first, but as globules of greenish-yellow or brownish-yellow color, sometimes smooth and resembling large yeast cells in the way they cluster together, and at other times covered with blunt points or spines. When these globules were observed, the precipitate was carefully washed with water, sometimes without removing from the test-tube, the last drops being taken up with filter paper, and then dissolved in warm diluted alcohol (3 parts of 95 per cent to 1 part water), which was not filtered, but decanted from the amorphous insoluble portion, and allowed to evaporate slowly to facilitate the formation of crystals. Unless these crystals could be obtained, the tests were considered negative, although Storer has pointed out that they are sometimes difficult to obtain, even when true mannose-hydrazone balls are present.

All quantitative determinations have been made in duplicate unless otherwise stated.

PENTOSAN PREPARATIONS.

Dulse.

A pure, water-soluble pentosan-preparation has been obtained from dulse (*Rhodymenia palmata*). After boiling in water, in an open vessel, with occasional stirring, for several hours, this dark, reddish-brown seaweed yielded a carbohydrate, non-mucilaginous in character, which could be precipitated from its solutions by alcohol. About 12 hours' boiling proved to be necessary for complete extractions. The hot, brown, watery extract was first filtered through gauze, and then through cotton, as it clogged up filter paper very quickly. This filtrate, concentrated to a syrup on a water bath, was poured while

still warm into about three times its volume of acetone, which experience showed to be a more satisfactory precipitant than alcohol. Most of the carbohydrate came down very soon, in large, flocculent, yellowish-white masses, but a portion remained in suspension as a fine white powder, which made filtration difficult. The bulk of the precipitate was therefore removed by filtering through three or four thicknesses of fine gauze, and the rest obtained by distilling off the acetone, concentrating the residue, and reprecipitating the carbohydrate in solution with acetone. This precipitate was very hygroscopic, and was therefore transferred immediately to 95 per cent alcohol. This was replaced by fresh alcohol after a few hours, and the whole boiled on a reflex condenser for half an hour. A yellowish, granular powder was thus obtained, which was filtered, washed with ether, and the adherent ether allowed to evaporate. It was then redissolved in a small volume of water, filtered hot through paper, on a jacketed funnel, reprecipitated with acetone, again put into 95 per cent alcohol, and finally into absolute alcohol, in which it was allowed to stand for several weeks. It was then filtered off, washed with ether, and dried *in vacuo* over sulphuric acid. The product was a cream-white powder, and apparently not at all hygroscopic. From about two kilograms of crude commercial dulse, approximately 75 grams of this material were obtained, and used subsequently for feeding experiments.

An attempt made to remove the dark red coloring matter by extraction with 1 per cent sodium carbonate, led to the discovery that this carbohydrate is readily extracted by dilute alkaline solutions. For preparations on a large scale, it was therefore found more satisfactory to use the following method, based on Salkowski's method (139, 140) of obtaining xylan and araban by precipitation with Fehling's solution. This method could be applied exactly as described, but there was an evident tendency for the carbohydrate to dissolve in the Fehling's solution.

The dulse was accordingly extracted with 1 per cent potassium hydroxide solution for 48 hours, with occasional stirring, the extract removed by a hand press, and the extraction with fresh alkali repeated for 24 hours.¹ These extracts were filtered through several thicknesses of gauze, and to this filtrate a solution of copper sulphate was added till the reaction was just neutral. A flocculent, bluish-green precipitate formed. Into this solution was stirred carefully the alkaline Rochelle salt-potassium hydroxide solution used for Fehling's solution, until the precipitate clumped together in heavy granular masses.

¹A third extraction contained so little of the material that it was discarded.

This was easily filtered off through gauze, as much liquid as possible removed by pressure, and the precipitate washed quickly with a little water to remove the excess of alkali. The carbohydrate was freed from its copper compound just as described by Salkowski (140). The precipitate was placed in a mortar and rubbed to a cream with diluted hydrochloric acid (1 volume of water to 1 volume of concentrated acid) the acid being added until all blue particles had disappeared. It was then poured into 90 per cent alcohol, the precipitate filtered off upon plaited paper and washed with 50 per cent alcohol, replaced in 90 per cent alcohol acidified with hydrochloric acid, and allowed to stand several hours to dissolve out the copper. It was then filtered, dissolved in dilute potassium hydroxide, and the dark brown, muddy solution filtered through paper on a hot funnel, the carbohydrate reprecipitated with acid alcohol, and redissolved and reprecipitated until free from copper. When it no longer came down readily in alcohol, acetone was substituted, in which it formed white fibrous masses resembling paper pulp. Washed with absolute alcohol and ether, and dried *in vacuo* over sulphuric acid, it became a cream-white powder. Both of these methods yielded a product readily soluble in cold water, forming a clear, limpid, amber-colored solution. It gave no color reaction with iodine, and contained no reducing substance. In Fehling's solution it formed a very flocculent white precipitate, was not precipitable by lead acetate, neutral or basic, in neutral solution, but formed a precipitate in alkaline solutions. A test for mucic acid gave negative results, but a strong furfurol reaction was obtained on boiling with hydrochloric acid, indicating the presence of pentosans. A 1-gram sample of material, prepared by the method first described, was tested quantitatively for pentosans. It contained 26.8 per cent moisture, and 2.48 per cent ash, and yielded 0.076 grams of phloroglucid, from which the yield of pentosans, according to Kröber's tables,¹ is calculated as 72 per cent. The phoroglucid precipitates were afterwards extracted with 95 per cent alcohol, according to Ellett and Tollen's² method for quantitative determination of methyl-furfur. The Gooch crucibles containing the precipitates were warmed 10 minutes to 60° C. with 15-20 cc. of alcohol, the extract filtered off, and the extraction repeated till the alcohol was colorless. The precipitates were then dried at 100° C. and weighed. The loss of weight was 0.0047 grams or 6 per cent of the original precipitate. The dulse preparation therefore contained a small amount of methyl-pentosan

¹Zeitschrift für physiologische Chemie, XXXVI, appendix.

²Berichte der deutschen chemischen Gesellschaft, Vol. 38, p. 492 (1905).

The products of hydrolysis were tested for fermenting sugar, with negative results, but after heating with phenyl-hydrazin-hydrochloride and sodium acetate, an abundant yield of osazones was obtained. These crystallized out only on cooling, were pale yellow, soluble in hot water only with great difficulty, but very soluble in alcohol, acetone, or pyridin. After four or five recrystallizations from alcohol, they melted at 152° C. and this melting point remained constant after ten or twelve recrystallizations. However, there were very minute points at which melting seemed to occur about 140° C. Under the microscope, clusters of long needles were seen, each with a tuft of small fine needles springing from its very tip. Dissolved in glacial acetic acid, and examined in a 100 mm. tube, these osazones showed no rotation of polarized light.

A very white sample of the dulse carbohydrate was used to determine its specific rotation. It contained 7.1 per cent moisture and 1.68 per cent ash. Two determinations were made, one on a 0.6 per cent solution and the other on a 1.0 per cent solution for which the polariscope readings in a 200 mm. tube were respectively -0.90° and -1.52° . The specific rotation, calculated from these readings was therefore $[\alpha]_D = -75.2^\circ$ and -76.2° , or corrected for moisture and ash, $[\alpha]_D = -82.4^\circ$ and -83.6° , average, -83° .

The rate of hydrolysis and maximum reducing power were determined as follows: 5 grams of the material dissolved in 500 cc. of 2 per cent hydrochloric acid were boiled in the usual way. At the end of two hours, and at intervals of one hour thereafter, 50 cc. portions were removed, neutralized and made up to 100 cc., and the amount of reducing sugar present determined as dextrose. The following results were obtained:

TIME OF BOILING.	SUGAR AS DEXTROSE.
Hours.	Per cent.
2	87.2
3	87.2
4	89.4
5	89.5

That the results vary greatly with the concentration, is shown by the fact that a 0.3 per cent solution boiled 5 hours yielded 67.1 per cent of sugar as dextrose.

Having established the fact that this dulse preparation consists of pentosans, with the properties described, further investigations into the exact chemical nature of the carbohydrates composing it were not considered within the province of this work.

Hawaiian Seaweeds.

Beside the dulse preparation, three seaweeds have been included in this group which yielded little or no soluble carbohydrates, namely, Limu Lipoa (*Haliseris pardalis*), Limu Eleele (*Enteromorpha intestinalis*) and Limu Pahapaha (*Ulva lactuca*, etc.).

Limu Lipoa. Limu Lipoa contained a small amount of non-mucilaginous carbohydrate, soluble in cold water as well as hot. It was precipitated by alcohol, in which it came down as a white fibrous mass. On hydrolysis, it yielded a dextro-rotatory fermenting sugar; a test with phenylhydrazin acetate for mannose was negative, as were tests for pentosans. The total amount of this carbohydrate was so small as to be almost negligible, as far as feeding experiments were concerned, hence the original washed material was used, after grinding to a powder in a coffee mill. It contained a very high percentage of inorganic matter because the thalli were so encrusted with calcareous substances, that it was impossible to remove them entirely by washing. This preparation gave a strong furfurol test, and a single quantitative test for pentosans gave the following results:

The sample, weighing 1 gram, contained 10.5 per cent moisture and 18.5 per cent ash. It yielded 0.161 grams of phloroglucid, which according to Kröber's tables ¹ is equivalent to 0.147 grams pentosans, or 14.7 per cent of the crude substance.

Tests for starch and reducing sugar were negative. Only a minute quantity of mucic acid was obtained; a quantity too small to purify and determine the melting point. The products of hydrolysis showed slight fermentation, which was doubtless due to the mannan of the water-extract.

A determination of the reducing power made in the same manner as already described, gave the results:

TIME OF BOILING.	SUGAR AS DEXTROSE.
Hours.	Per cent.
1½	Very little
3	14.3
4	14.7
6	12.9
8	12.8

Limu Eleele. Limu Eleele yielded no appreciable amount of water-soluble carbohydrate, even after boiling 3 or 4 hours. The dried

¹ Zeitschrift für physiologische Chemie, XXXVI, appendix.

seaweed was therefore simply finely ground for use in feeding experiments.

It gave a strong furfural test, but yielded a mere trace of mucic acid. Tests for starch and reducing sugar were negative. The products of hydrolysis contained no fermenting sugar. From this it was evident that the hemicelluloses were chiefly pentosans.

Determination of the reducing power gave the following results:

TIME OF BOILING.		SUGAR AS DEXTROSE.
Hours.		Per cent.
2		16.8
3		16.9
4		18.1
5		16.8

Limu Pahapaha. *Ulva lactuca* is said by Röhmann (134) to contain a water-soluble methyl-pentosan, rhamnosan; but if this occurs in *Limu Pahapaha*, it must be in very small amount, as an extract of 50 grams of the dried seaweed, made by boiling 3 or 4 hours, gave very little residue on evaporation to dryness. For feeding experiments, the dry crude substance was simply ground to a powder. Like *Limu Eleele*, it gave a strong furfural test, but yielded no mucic acid. Starch was present, but no reducing sugar. Fermentation with yeast was marked in 12 hours, probably due chiefly to the hydrolysis of the starch.

Determination of reducing power gave the following results:

TIME OF BOILING.		SUGAR AS DEXTROSE.
Hours.		Per cent.
2		28.8
4		31.8

GALACTAN PREPARATIONS.

Irish Moss.

The carbohydrates of Irish moss are, as already noted, readily soluble in cold water, after the salt has been removed from the seaweed. By allowing the moss to stand for 24 hours in cold water (about 10 liters to 250 grams of dry substance), an almost colorless, semi-transparent, mucilaginous extract was obtained. By straining this off through gauze, and allowing it to stand over night, for minute particles of cellulose held in suspension to settle, a solution almost entirely free from insoluble material was obtained by decantation.

This was considered sufficiently pure for feeding experiments, and was quickly dried by pouring into broad shallow dishes and placing over a steam radiator. It formed yellowish, translucent scales, which were easily removed, and finely ground.

Subsequent extractions were made in a steam sterilizer, heating several hours at a time. Tests showed that the carbohydrate was not hydrolyzed by this repeated subjection to high temperature. The several extracts were first strained off through gauze and then filtered hot through cotton, to remove the cellulose particles. As these clogged even cotton filters very rapidly, it was found most satisfactory to let the extracts stand over night, decant off the supernatant fluid as far as possible, and filter in a water-jacketed funnel. Solutions containing over 1 per cent dry substance could not be filtered through paper. For experiments where a perfectly clear fluid was desired, a $\frac{1}{2}$ per cent solution was filtered hot through plaited paper, and then concentrated on a water bath to the desired strength. One per cent solutions formed a soft jelly on cooling; 2 per cent solutions, a firm jelly.

Even when evaporated to a thick syrup, the carbohydrates of the Irish moss extract are not readily precipitated by comparatively large volumes of 95 per cent alcohol, but form a voluminous, transparent, gelatinous mass. This was found to be more or less characteristic of all the galactans examined. They could be brought down most satisfactorily by addition of sodium chloride to the extract before pouring it into the alcohol. In this way a white precipitate of fine fibers was obtained from the moss. The carbohydrate could also be precipitated by saturation with potassium acetate, and freed from inorganic salts by dialysis, according to the method described by Pohl (263). It could not be precipitated by Fehling's solution, nor by lead acetate in neutral solution.

Owing to the opacity of its solutions, and to the fact that its gelatinizing property made the use of very dilute solutions necessary, no satisfactory determination of its specific rotation could be obtained. A 0.5 per cent solution, clarified with alumina cream, and examined in a 200 mm. tube, showed a rotation of $+0.34^\circ$, and other trials gave positive evidence that it was dextro-rotatory. The products of hydrolysis were also dextro-rotatory, and yielded osazones, which after one recrystallization from alcohol, had a melting point of 184° - 185° C.

The carbohydrate gave a red-violet color with iodine, and contained no reducing sugar. A faint furfural test was obtained. Oxidation with nitric acid gave a rich yield of mucic acid. Since Hädiike,

Bauer and Tollens (185), and Müther (200) have already shown that Irish moss contains galactan, levulan, dextran and pentosan groups, these tests were simply verifications of some of their observations.

Determination of the reducing power gave the following results:

TIME OF BOILING.	SUGAR AS DEXTROSE.
Hours.	Per cent.
2	45.6
3	48.6
4	45.8

Hawaiian Seaweeds.

- Limu Manauea (*Gracilaria coronopifalia*),
- Limu Huna (*Hypnea nidifica*),
- Limu Akiaki (*Ahnfeldtia concinna*),
- Limu Kohu (*Asparagopsis sanfordiana*),
- Limu Uualoli (*Gymnogongrus*).

These five seaweeds all contained soluble carbohydrates, which were extracted by boiling in water in an open vessel over a free flame for two hours or longer. Limu Manauea, Limu Huna, and Limu Akiaki, which consist largely of soluble gelatinizing hemicelluloses, yielded most of these on boiling two or three hours. The extracts were strained off through gauze, filtered hot through cotton, and dried in thin sheets as described for Irish moss. While the preparations were dark colored, and had a decided "sea" flavor, they were not unpleasant, and were used in feeding experiments without further purification. As already stated, the carbohydrates were not easily precipitated with alcohol unless a neutral salt (as sodium chloride) was present.

Limu Kohu and Limu Uualoli contained only a small proportion of soluble hemicelluloses, and this was obtained only after boiling 8 to 24 hours. The extracts were also much less gelatinous in character. The thalli of Limu Kohu are almost like wire when dry, and remain tough and hard even after many hours' boiling. The extracts of these two species were more readily precipitated by alcohol than the others, but the precipitation was greatly facilitated by adding sodium chloride. The carbohydrate of Limu Kohu was precipitated as a white cheese-like cake, floating on the surface, while that of Uualoli came down as a mass of coarse white fibers. These precipitates were transferred to absolute alcohol, and after standing several days, were filtered off, washed with ether and dried at 40°-50° C. The

Kohu preparation should have been dried *in vacuo*, for it proved to be slightly hygroscopic, and instead of remaining a fine white powder, became somewhat brownish. The Uualoli preparation dried easily to a grayish white, light, fibrous mass.

Tests for starch and reducing sugar were negative on all these substances. Tests for galactans and pentosans were positive in every case. Three-gram samples of the air-dry preparations of Limu Akiaki, Limu Uualoli and Limu Kohu respectively yielded 0.53 grams, 0.92 grams and 0.64 grams of mucic acid, recrystallized once from ammonium carbonate.¹ The products of hydrolysis in no case contained fermenting sugars. It is evident therefore, that these five preparations from the foregoing Hawaiian seaweeds consisted chiefly of galactans, accompanied by some pentosan-groups. From the frequency with which methyl-pentosans have been shown to occur in all seaweeds previously investigated, it is very likely that they occur in all these varieties and it would be desirable to make tests for methyl-pentosans.

Determinations of the reducing power were made, as shown in the following table:

SPECIES OF SEAWEED.	SUGAR AS DEXTROSE.			
	1 Hour.	2 Hours.	3 Hours.	4 Hours.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Limu Manauca.....		41.9	44.6	39.8
Limu Huna.....	43.6	58.4	55.6	30.8
Limu Akiaki.....	36.0	36.0	34.0	

Slippery Elm. For the preparation of the carbohydrate which forms the mucilaginous extract of slippery elm bark, pieces of the latter were torn into narrow strips and allowed to stand over night in cold water,² and then the mucilage expressed by squeezing through gauze. This process was repeated until the bark became a mass of separate fibers. The mucilaginous principle swells in cold water to a transparent jelly, but is soluble only to a very limited extent. It was found impossible to filter it, even through gauze, and therefore, although it contained small particles from the disintegrated bark

¹For method cf. Bull. No. 107, p. 55, Bureau of Chemistry, United States Dept. of Agriculture.

²It was found impossible to extract the mucilaginous principle in hot water.

fibers, the carbohydrate was precipitated by pouring the thick slimy mass into about six times its volume of 95 per cent alcohol. After standing some hours, a transparent, gelatinous precipitate settled to the bottom, and was filtered off through several thicknesses of gauze. Dehydrated by means of absolute alcohol and ether, it formed a grayish-brown powder. This was found to be soluble in dilute alkali, and was subsequently purified by dissolving in 1 per cent potassium hydroxide, filtering through cotton and reprecipitating with 95 per cent alcohol. The product was somewhat lighter in color than at first, but still far from white. It was soluble in hot Fehling's solution, but precipitable with lead acetate. It gave no color with iodine, although a small amount of starch was present in the original bark.

Furfurol tests were faint showing only traces of pentosans, but the yield of mucic acid was large, 0.15 grams of mucic acid being obtained from 1 gram of the air dry powder.

The products of hydrolysis were dextro-rotatory and contained no fermenting sugars. Hence this preparation consisted chiefly of galactan.

A MANNAN PREPARATION.

Since none of the algae which form the basis of these studies yielded mannan, save *Limu Lipoa*, and that in amounts inadequate for the experiments proposed, this hemicellulose was obtained in soluble form from salep. Both the small, horny dried tubers and the grayish-white powder made from them, were purchased from Schieffelin & Co., New York.

A preparation of pure mannan was made in the following way:

The tubers were soaked in cold water 24 hours, washed thoroughly and ground in a meat chopper. To this mass, cold water was added in large volume, and the whole allowed to stand over night, then the dissolved mannan filtered off through gauze. According to Hilger (254), the extract made in this way should contain no starch. But when the tubers are heated before drying, the starch is made soluble, and in this instance the cold water extract gave a blue color with iodine.¹ Hence subsequent extractions were made with hot water on a water bath, for several hours. The salep swells very much in water so that a very large portion was required to get the mannan all into

¹Salep tubers purchased since this work was done yielded only a trace of starch in the cold water extract.

solution.¹ The extracts, strained through cheese cloth, were digested 24 hours with malt diastase to free from starch, then concentrated to a thick syrup on a water bath, and poured into three times their volume of 95 per cent alcohol. A voluminous, flocculent, and somewhat fibrous, snow-white precipitate formed, which was filtered off, pressed free from alcohol, redissolved in hot water, and reprecipitated. (This was done largely to free it from sugar produced by the digestion of the starch.) It was then transferred to absolute alcohol and allowed to stand three or four days, after which it was washed with ether, and dried in a vacuum desiccator. A somewhat coarse white powder resulted, containing 6.94 per cent moisture and 0.74 per cent ash.² It swelled up very readily in water, but dissolved exceedingly slowly to a colorless, semi-transparent mucilaginous solution, which did not reduce Fehling's solution, and examined in the polariscope, after clarification with alumina cream, appeared optically inactive. However, on reprecipitating the carbohydrate with alcohol, and examining the alcoholic filtrate, sugar was found to be present in small amount. A solution absolutely sugar-free became optically active. A sample in which the sugar had been removed by fermentation with yeast, was used to determine the specific rotation. The following results were obtained: (1) A 2 per cent solution in a 200 mm. tube read -1.59° ; applying corrections for moisture and ash, $[\alpha]_D = -43.1^\circ$. (2) A sample containing in 100 cc. 0.5868 grams mannan dried to constant weight at 105°C . read -0.48° ; corrected for 0.4 per cent ash, $[\alpha]_D = -43.8^\circ$. According to Thamm (276), salep extract is inactive. In the above experiments, the levo-rotatory nature of the mannan was at first obscured by the presence of traces of reducing sugar formed by the hydrolysis of the starch, which could not be detected by testing directly by Fehling's solution. Thamm, however, in several ways carefully tested salep hydrolysis products for dextrose with negative results, so that the only way to account for these conflicting results seems to be to attribute it to difference in the specimens of *Orchis* which furnished the mannan.

Salep-extract is readily precipitated by Fehling's solution in flocculent white masses. It is not precipitated by lead acetate in neutral solution (nor, according to Thamm [276], in solutions of other neutral salts), but is precipitated by basic lead acetate.

A furfural test was faintly positive, verifying the report of traces of pentosans by Tollens and Widtsoe (163), and also by Thamm (276).

¹15 liters of water to 100 grams salep powder, according to Thamm (276).

²Thamm found 0.483 per cent.

The products of hydrolysis were dextro-rotatory and contained sugar fermentable with yeast. A rich yield of mannose-hydrazone was obtained with phenyl-hydrazine acetate, melting on recrystallization at 188° C. According to Thamm (276), salep extract yields exclusively mannose on complete hydrolysis.

Hydrolyzed for three hours, the reducing power of this mannan was 91.6 per cent.

Determinations of ash, moisture, starch, and mannan were made on the salep obtained in the form of a powder. Starch and mannan were determined as follows: 1 gram of air dry powder was boiled in 250 cc. water, and after cooling to 37.5° C., the starch hydrolyzed with malt diastase, dialyzed sugar-free. The solution was then filtered, concentrated to small volume, and the mannan precipitated with absolute alcohol. The precipitate was filtered off, dissolved in a little water and reprecipitated, to obtain any sugar retained in the first precipitation. The mannan was then dried at 100° C. and weighed. The filtrates were combined, freed from alcohol, hydrolyzed with 2 per cent hydrochloric acid 45 minutes to convert all the maltose to dextrose, and sugar determined by Allihn's method. The results of these analyses are shown in the following table:

<i>Per cent</i>		<i>Per cent</i>	
Moisture.....	0.77	Starch.....	26.4
Ash.....	8.9	Mannan.....	19.5

According to Dragendorf¹ the composition of Orchis tubers is as follows:

<i>Per cent</i>		<i>Per cent</i>	
Starch.....	27.3	Protein.....	4.9
Mucilage.....	48.1	Cellulose.....	2.4
Sugar.....	1.2		

Thamm also reports a yield of 40-45 per cent mucilage from the salep powder used in his investigations. Hence the powder used in this the present experiment was for some reason very deficient in mannan.

Its reducing power was as follows:

TIME OF BOILING.	SUGAR AS DEXTROSE.
<i>Hours.</i>	<i>Per cent</i>
2	74.2
3	75.8
5	75.8

¹Cited in the National Dispensatory (1884), also by Thamm (276).

A LEVULAN PREPARATION.

Commercial Squills, consisting of the dried and broken leaves of the bulbs of *Scilla maritima* (or *Urginea Scilla Stenh.*) yield, as discovered by Schmiedeberg (318), the levulan sinistrin. They were finely ground in a coffee mill, and the sinistrin prepared according to Schmiedeberg's directions. To the dry powder sufficient water was added to make a thin cream, and then a saturated lead acetate solution until further addition produced no precipitate. To the clear, straw-colored filtrate, freed from lead with hydrogen sulphide, was added freshly prepared milk of lime, with constant stirring, until a somewhat creamy consistency was produced. To facilitate the formation of sinistrin-calcium carbonate, this mixture was concentrated on the water bath for some time (as suggested by Reidemeister) [314]. The precipitate was then sucked dry on a Büchner funnel, washed thoroughly with cold water (being rubbed up in a mortar for the purpose), again sucked dry, rubbed to a cream with water, and treated with carbon dioxide until the fluid was no longer alkaline to litmus. After heating to facilitate the complete separation of the calcium carbonate, the sinistrin in solution was filtered off, a little oxalic acid carefully added to remove the last traces of lime, and the solution then decolorized with charcoal, and evaporated to a syrup at a temperature of about 40° C. From this solution the sinistrin was precipitated with 95 per cent alcohol, as a white gummy mass. Transferred to absolute alcohol, and allowed to stand 24-36 hours it became very tenacious, but on longer standing, with occasional stirring, it grew brittle, and finally crumbled to a coarse white powder, which was dried in a vacuum desiccator. This material was readily soluble in cold water. (According to Schmiedeberg [318], even solutions of 20-30 per cent are not syrup-like.) It gave no color with iodine, did not reduce Fehling's solution, and was not precipitated by it. This preparation, at first, contained 13 per cent moisture and 0.76 per cent ash. Determination of the specific rotation then gave the following results: A 2 per cent solution in a 200 mm. tube, read -1.32° ; corrected for moisture and ash, $[\alpha]_D = -38.2^\circ$. After longer standing (three months) over sulphuric acid, the moisture content was 4.8 per cent, and determination of specific rotation gave the following results: A 1 per cent solution in a 200 mm. tube, read -0.55° ; corrected for moisture and ash, $[\alpha]_D = -29.1^\circ$. Schmiedeberg (318) found the average for $[\alpha]_D = -41.4^\circ$, and Reidemeister (314), $[\alpha]_D = -34.6^\circ$. It is impossible to account for these differences. Reidemeister claims

that the rotation increases on standing, but in these solutions there was no change in 48 hours, at room temperature.

On hydrolysis, sinistrin yields a levo-rotatory, reducing sugar, fermenting with yeast. Schmiedeberg (318) reports this as a mixture of levulose and an inactive sugar, but Reidemeister (314) declares that it is neither a mixture of levulose and an inactive sugar, nor of levulose and dextrose, in spite of the fact that he found for it $[\alpha]_D = -88^\circ$, while for levulose, $[\alpha]_D = -106^\circ$, a difference for which he is unable to account.

SUMMARY.

The composition of the preparations which have been described is best shown in the following table:

SOURCE OF MATERIAL.	NATURE OF CARBOHYDRATES PRESENT.				
	Pentosans.	Galactan.	Mannan.	Levulan.	Dextran.
Dulse (<i>Rhodymenia Palmata</i>)	+				
Limu Lipoa (<i>Haliseris Pardalis</i>)	+				
Limu Eleele (<i>Enteromorpha intestinalis</i>)	+				
Limu Pahapaha (<i>Ulva lactuca</i> , etc.)	+				(Starch)
Irish Moss (<i>Chondrus crispus</i>)	Trace	+		+	+
Limu Manauea (<i>Gracilaria coronopifolia</i>)	+	+			
Limu Huna (<i>Hypnea nidifica</i>)	+	+			
Limu Akiaki (<i>Ahnfeldtia coccinea</i>)	+	+			
Limu Uualoli (<i>Gymnogongrus</i>)	+	+			
Limu Kohu (<i>Asparagopsis sanfordiana</i>)	+	+			
Slippery Elm (<i>Ulmus</i>)		+			
Salep (<i>Orchis</i>)	Trace		+		
Squills (<i>Urginea scilla</i>) [Sinistrin]				+	

The foregoing observations correspond with those of König and Bettels (8), in that the marine algae all yield pentosans, and frequently galactans. The gelatinizing principle in every case appears to be due to the galactan groups. No specific tests have been applied

for fructose, the polysaccharide of which also appears to be common in algae, but the absence of fermenting sugar in all the algae except Limu Lipoa, indicates that if present, it is in too small amount to be detected in the hydrolysis products of 5-10 grams of crude material.

The reducing power has been determined on each substance used in feeding experiments; the results of all determinations are summarized in the following table:

SUBSTANCE.	SUGAR AS DEXTROSE AFTER BOILING.						
	1 Hour.	2 Hours.	3 Hours.	4 Hours.	5 Hours.	6 Hours.	8 Hours.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
Dulse.....		87.2	87.3	89.4	89.5.		
Limu Lipoa.....			14.3	14.7		12.9	12.8
Limu Eleele.....		16.8	16.9	18.1	16.8		
Limu Pahapaha.....		28.8		31.8			
Irish Moss.....		45.6	48.6	45.8			
Limu Manauea.....		41.9	44.6	39.8			
Limu Huna.....	43.6	58.4	55.6	30.6			
Limu Akiaki.....	36.0	36.0	34.0				
Salep (Powder).....		74.2	75.8		75.8		
Salep (Pure mannan).....			91.6				

BACTERIOLOGICAL INVESTIGATIONS.

INTRODUCTION.

It is an accepted fact that even cellulose, with its high powers of resistance, is to some extent decomposed in the alimentary tract by bacteria. It is therefore reasonable to expect that the less resistant hemicelluloses will also be attacked and decomposed by bacteria. The object of these experiments has been to throw some light on the problem as to what organisms are most likely to effect such a decomposition, and whether there is an appreciable production of sugar as a result of bacterial activity. The four classes of hemicelluloses under special investigation have been represented by the following substances:

- | | | | |
|----------------|---------------|-----------------|------------|
| Pentosans..... | Dulse. | Mannans..... | Salep. |
| Galactans..... | } Irish Moss. | Levulans..... | Sinistrin. |
| | | } Limu Manauea. | |

Both aerobic and anaerobic cultures have been made, in neutral, faintly alkaline, and faintly acid reaction, with solutions made from the carbohydrates alone, and with the addition of small amounts of such nutrients as beef extract or peptone to facilitate the growth of the organisms.

Anaerobic cultures in test tubes have been made by the Wright method; anaerobic cultures in Erlenmeyer flasks, by passing a stream of hydrogen through for half an hour, and then sealing hermetically.

The aerobes which have been employed all occur in the human digestive tract. Both aerobic and anaerobic cultures from the faeces of human subjects have also been used, in conjunction with soil bacteria from street sweepings.

Tests for the presence of reducing sugar have been made by precipitating the carbohydrates in solution with absolute alcohol, evaporating the alcoholic extract to dryness, taking up the residue in 2 or 3 cc. of water, and boiling two minutes with Fehling's solution.

Suitable controls have been used in all cases.

TRIALS WITH PURE CULTURES OF AEROBES.

One per cent solutions of the preparations from dulse, Irish moss and salep, neutral, acid, and alkaline in reaction, and consisting of, (1) pure carbohydrate; (2) carbohydrate plus $\frac{1}{4}$ per cent beef extract and $\frac{1}{4}$ per cent sodium chloride; (3) carbohydrate plus 1 per cent peptone and $\frac{1}{4}$ per cent sodium chloride, have been used as culture media. Five cc. portions of each of these solutions were placed in test-tubes with a pipette, and inoculated with the following organisms: *B. Coli communis*, *B. Pyocyaneus*, *B. Prodigiosus*, *B. Proteus vulgaris*, *B. Pyogenes foetidus*.

To approximate the conditions in ordinary digestion of these carbohydrates, they were incubated for three days at a temperature of 37.5° C. At the end of this time, nearly all gave evidence of some bacterial growth. Salep-peptone cultures of *B. Pyocyaneus* showed a brilliant green; salep solutions containing *B. Pyogenes foetidus*, and *B. Coli* in alkaline-beef extract media, had changed from transparent colorless solutions to an opaque white jelly insoluble in water.

The carbohydrates were then precipitated with alcohol, and after standing several days were compared with controls similarly prepared, to see whether any change could be observed in the nature or amount of carbohydrate. The results were in all cases negative. These precipitates were then transferred to small folded filter papers of uniform

weight, previously prepared. The alcoholic filtrates were tested for sugar; the precipitates were dried, and their weight compared with that of the control. It was thought that this rather crude method would show whether any considerable amount of the carbohydrate had disappeared. The results were so largely negative that weighings of every precipitate were not made. There seemed to be a slight loss of dulse, in some of the cultures of *B. Proteus vulgaris*, *B. Pyogenes foetidus*, and *B. Coli communis*, but repetition of these experiments allowing the organisms in question to grow two weeks, not only in dulse but also in salep media, did not justify any conclusion that an appreciable amount of carbohydrate had disappeared.

All tests for reducing sugar were negative.

Four per cent solutions of Irish moss, and two per cent solutions of limu manauca were then prepared, with reactions and additions of nutrient material as described in the first series of experiments. These formed firm jellies, which were used to study the possibility of liquefaction or gas formation. Stab cultures were made, and grown at a temperature of 25°-30° C. for one to three weeks. No liquefaction or gas formation was observed in any case.

TRIALS WITH MIXTURES OF AEROBES.

Mixtures of *B. Pyocyaneus*, *B. Prodigiosus*, *B. Proteus vulgaris*, and *B. Pyogenes foetidus*, were used, also mixtures of faecal and soil bacteria. These were first inoculated into nutrient bouillon, the former from pure cultures, the latter from human faeces and street sweepings, and incubated 24 hours. Five cc. portions of these cultures were then introduced into 50 cc. of neutral solutions of each of the different carbohydrates, in small Erlenmeyer flasks, and these cultures allowed to grow for four weeks at 37.5° C. At the end of this time, no marked change had taken place save in the salep culture of *B. Pyocyaneus*, *B. Proteus vulgaris*, *B. Pyogenes foetidus* and *B. Prodigiosus*. This had changed from a colorless, semi-transparent, slightly mucilaginous fluid, to a firm, white opaque jelly, insoluble in water, but readily soluble in dilute alkali; a phenomenon already observed with this carbohydrate in cultures of *B. Coli communis* and *B. Pyogenes foetidus*. No liquefaction had taken place with Irish moss nor limu manauca.

The carbohydrates were then precipitated with alcohol, the alcoholic extracts tested for sugar, and the precipitates hydrolyzed by boiling with 2 per cent hydrochloric acid, neutralized, made up to a

definite volume, and examined in a polariscope. The results of these experiments are shown in the following table. Mixtures of *B. Pyocyaneus*, *B. Prodigiosus*, *B. Proteus vulgaris* and *B. Pyogenes foetidus* are designated A, and mixtures of faecal and soil bacteria, B.

SUBSTANCE	BACTERIAL CULTURE	REDUCTION OF FEHLING'S SOLUTION.	ROTATION AFTER HYDROLYSIS.	
			Experiment.	Control.
Dulse	B	....	+0.13°	+0.20°
Irish Moss.....	A	....	+0.20°	
Irish Moss.....	B	....	+0.27°	+0.20°
Limu Manauca	A	....	Not determined.	
Salep	A	....	Not determined.	
Salep	B	+	+0.17°	+0.20°
Sinistrin.....	A	....	-0.97°	-0.97°

The action of putrefactive organisms upon the dulse preparation was also studied, according to the method used by Slowtsoff (154) in the case of xylan. One hundred grams of chopped lean beef and 10 grams of sodium carbonate were added to 1 liter of water, and the mixture allowed to stand in a warm place for three days. Two hundred and fifty cc. were then removed for a control, and to the remainder 0.5 gram of dulse was added. This solution gave a strong pentosan reaction; the control was pentosan-free. The two solutions were put in a warm place, and tested daily for pentosans. After five days' digestion, the reaction of the dulse solution was very much fainter than at first, but it did not entirely disappear till the twelfth or thirteenth day. Slowtsoff found that xylan disappeared in nine or ten days, but his solution was kept at a temperature of 40° C., while these mixtures remained at a temperature of from 30° to 35° C., a condition less favorable for rapid decomposition.

Solutions of Irish moss were digested with faecal mixtures in the following manner: Human faeces were rubbed to a mud with water. Ten cc. portions of this material were added to flasks containing 50 cc. of a 1 per cent "moss" solution, and allowed to digest in a warm place for 24 hours. A portion of water inoculated in the same way was used as a control. Small portions of these solutions were then evaporated nearly to dryness, extracted with alcohol, and tested for reducing sugar. The results were wholly negative.

That limu manauca is not entirely resistant to the action of putrefying organisms is shown by the following: A solution was made

up to contain 2 per cent of the air dry extract, 1 per cent peptone, $\frac{1}{4}$ per cent beef extract and $\frac{1}{4}$ per cent sodium chloride. This could be filtered through paper only on a hot, water-jacketed funnel, from which it dropped as a clear, amber-colored jelly. After standing unsterilized over night in a warm room, this was found to be entirely broken up by the formation of gas throughout the whole mass. The reaction, which had been neutral, was now acid to litmus. This material was placed in a flask and allowed to stand for two months, at the end of which time, the greater portion was liquefied, the former lumps of jelly being reduced to small particles distributed throughout the liquefied portion. Alcoholic extracts did not reduce Fehling's solution. A sterile preparation of the plain manauca extract in test tubes was inoculated with some of this material, but without producing the same striking results. There were evidences of growth, but none of liquefaction or gas formation, in the course of two weeks.

TRIALS WITH ANAEROBES.

The action upon Irish moss of pure cultures of the powerful putrefactive organisms *B. Putrificus*, *Bienstock*, *B. Maligni œdematis*, and *B. Anthracis symptomatici*, was tried in the following way. A 4 per cent solution of the moss was prepared, which would not become liquefied at a temperature of 30°-35° C. From this material culture media were prepared, neutral, alkaline, and acid in reaction, using the solution plain, and with the addition of $\frac{1}{4}$ per cent beef extract and $\frac{1}{4}$ per cent salt, or 1 per cent peptone and $\frac{1}{4}$ per cent salt. Test tubes were inoculated from fresh, active cultures, and the organisms allowed to grow for one to three weeks, being examined at first daily, and later every three or four days, for liquefaction and gas formation. The results were negative in all cases, save that in the peptone media an occasional small bubble was seen, with cultures of the bacilli of malignant œdema and symptomatic anthrax. However, the same phenomena were observed in peptone-agar tubes used as controls.

Mixtures of *B. Anthracis symptomatici* and *B. Maligni œdematis* were tried upon solutions of dulse, Irish moss, salep and sinistrin, in the following way: Small Erlenmeyer flasks containing 50 cc. of 1 per cent solutions of each of these carbohydrates, and 5 cc. of ordinary nutrient bouillon, were inoculated with fresh cultures of these organisms, rendered anaerobic, and incubated for four weeks at 37.5° C. On inspection, no change was apparent. The carbohydrates were removed, the alcoholic extracts examined for reducing sugar, and

the carbohydrate residues hydrolyzed and examined in the polariscope, as in similar trials with aerobes. The results are shown in the following table:

NAME OF SUBSTANCE.	REDUCTION OF FEHLING'S SOLUTION.	ROTATION AFTER HYDROLYSIS.	
		Experiment.	Control.
Dulse.....		Lost by accident	
Irish Moss.....		+ 0.24°	+ 0.20°
Salep.....	+	+ 0.13°	+ 0.20°
Sinistrin.....	+	- 0.27°	- 0.97°

Mixtures of soil and faecal bacteria were also tried, the experiments being carried out just as described for mixtures of the bacilli of symptomatic anthrax and malignant œdema. The results are shown in the following table:

NAME OF SUBSTANCE.	REDUCTION OF FEHLING'S SOLUTION.	ROTATION AFTER HYDROLYSIS.	
		Experiment.	Control.
Dulse.....		+ 0.13°	+ 0.20°
Irish Moss.....		+ 0.20°	+ 0.20°
Salep.....	+	+ 0.03°	+ 0.20°

DISCUSSION AND SUMMARY.

It seems reasonable to expect, that if the hemicelluloses used in these trials were readily attacked by micro-organisms, there would have been some evidence of change in three days, if conditions for growth were favorable as regards reaction and temperature; but although the concentration of the solutions was moderate, the reaction varied, and temperature 37.5° C., results were negative, even in the cases where nutrients were added to facilitate bacterial growth. Apparently all of the material was recovered in unaltered condition, save in certain instances where salep underwent an insoluble modification.

In trials where the cultures were allowed to grow from one to three weeks, no difference in the results could be detected, by the methods employed. In solid media there was no liquefaction and practically no gas formation, except in the case of the peptone-beef extract preparation of limu manaua, on exposure to the air.

Marked evidences of change were observed in one trial with a putrefactive mixture (on dulse), and in some of the four-week cultures.

Irish moss was the most thoroughly investigated and proved the most resistant. In the long experiments (4 weeks) where the other carbohydrates suffered more or less change this one remained apparently unaltered. The results of this series are summarized in the following table:

Irish Moss.

CULTURES USED.	REDUCTION OF FEHLING'S SOLUTION.	ROTATION OF UNALTERED CAR- BOHYDRATE AFTER HYDROLYSIS.	
		Irish Moss.	Control.
Mixture of Pure Aerobes.....		+ 0.20°	+ 0.20°
Mixture of Faecal and Soil Bacteria (aerobic).....		+ 0.27°	+ 0.20°
Mixture of Bacilli of Malignant Oedema and Symptomatic Anthrax..		+ 0.24°	+ 0.20°
Mixture of Faecal and Soil Bacteria (anaerobic).....		+ 0.20°	+ 0.20°

The single experiment with the galactan, limu manaua, under the same conditions, with the mixture of pure aerobes, gave similar results, but the fact that liquefaction occurred in the peptone-beef extract culture medium after exposure to the air, shows that general conclusions as to the behavior of galactans cannot be drawn from study of a single representation of the class. We have, however, further proof that the galactans are not easily decomposed by bacteria, in the fact that aqueous solutions of all the galactans included in the present series, could be left several days in the warm atmosphere of the laboratory without any apparent change taking place; and in the fact that agar-agar, so widely used in bacteriological laboratories on account of its indifference to bacterial action, is a member of the galactan group. It has been suggested¹ that extracts of other seaweeds might prove good substitutes for agar-agar as culture media, if fully investigated. So far, the greatest objection to use of Irish moss in this way is that it tends to liquefy at body temperature; strong solutions (4 per cent) can, however, be kept fairly firm at a

¹Cf. Reed (18).

temperature of 30° C. The extract of limu manauca is free from these objections, but extensive experiment is still necessary to demonstrate its powers of resistance.

The soluble dulse pentosan is certainly decomposed not only by putrefactive organisms under the most favorable conditions (*e.g.*, in meat mixtures), but by aerobes and anaerobes in solutions where the carbohydrate is the chief source of nutriment. The results of the four weeks' digestions are summarized in the following table:

CULTURES USED	REDUCTION OF FEHLING'S SOLUTION.	ROTATION OF UNALTERED CARBOHYDRATE AFTER HYDROLYSIS.	
		Dulse.	Control.
Mixture of Faecal and Soil Bacteria (aerobic)	+0.13°	+0.20°
Mixture of the Bacilli of Malignant Oedema and Symptomatic Anthrax..	(Lost by Accident)	+0.20°
Mixture of faecal and Soil Bacteria (anaerobic)	+0.13°	+0.20°

In the present studies, this pentosan stands second to the galactans in degree of resistance.

Sawamura (267) thought that he observed a slight hydrolysis of mannan by *B. Prodigiosus*, an observation which has not been verified in these experiments. No reducing substance was detected in the three-day cultures nor the four-weeks cultures, in which this organism was present. The opaque jelly, insoluble in water, formed from salep by the action of *B. Coli communis*, *B. Prodigiosus*, and mixed cultures containing these organisms, resembles an intermediary product of the acid hydrolysis of salep-mannan described by Thamm (276). He isolated and examined two such products, one forming an opalescent solution in water, the other insoluble, but passing over into the soluble form by treatment with dilute alkali; both were anhydrides of mannose. It seems reasonable to inquire whether this insoluble material produced by bacterial action may not be regarded as an early stage in the hydrolysis of the carbohydrate under consideration, especially in view of the fact that in all the other four-week trials a very definite reduction of Fehling's solution was noted, corresponding

in strength with the loss of unaltered carbohydrate, as shown in the following summary:

Salep.

CULTURES USED.	REDUCTION OF FEHLING'S SOLUTION.	ROTATION OF UNALTERED CARBOHYDRATE AFTER HYDROLYSIS.	
		Salep.	Control.
Mixture of Pure Aerobes.....	(Insoluble jelly)	Not determined	
Mixture of Faecal and Soil Bacteria (aerobic).....	+	+ 0.17°	+ 0.20°
Mixture of the Bacilli of Malignant Oedema and Symptomatic Anthrax..	+	+ 0.13°	+ 0.20°
Mixture of Faecal and Soil Bacteria (anaerobic).....	+	+ 0.03°	+ 0.20°

These experiments give some grounds for expecting the hydrolysis of salep in the alimentary tract, through the action of bacteria.

Two experiments with sinistrin gave the following results:

Sinistrin.

CULTURES USED.	REDUCTION OF FEHLING'S SOLUTION.	ROTATION OF UNALTERED CARBOHYDRATE AFTER HYDROLYSIS.	
		Sinistrin.	Control.
Mixture of Pure Aerobes.....		- 0.97°	- 0.97°
Mixture of Bacilli of Malignant Oedema and Symptomatic Anthrax.....	+	- 0.27°	- 0.97°

Sinistrin is therefore hydrolyzed by the anaerobic putrefactive organisms, but further experiments are necessary to determine how readily this change takes place.

PHYSIOLOGICAL INVESTIGATIONS.

In the physiological experiments, attempts have been made to answer the following questions: (1) To what extent are hemicelluloses digested by animal and vegetable enzymes? (2) Can they be absorbed and utilized without intervention of the alimentary tract?

(3) Do they reappear in the faeces after administration *per os*? The various experiments will accordingly be discussed in these three groups: (1) Trials with Enzymes; (2) Parenteral Trials; (3) Feeding Experiments.

TRIALS WITH ENZYMES.

Approximately 1 per cent solutions of the various hemicelluloses (with the exception of Limu Lipoa, which was finely ground and suspended in water), have been digested for 24 hours at 37.5° C. in the presence of toluene, with the following enzymes: (1) Filtered human saliva. (2) Malt diastase, dialyzed sugar-free. (3) "Taka" diastase (*Eurotium oryzae*). (4) Chloroform extract of pig's pancreas. (5) Fresh pancreatic juice of dogs. (6) Chloroform water extract of dog's intestines. (7) Glycerol extract of pig's stomach.

Digestions have also been made with 0.2 per cent hydrochloric acid, to determine whether any of the action of the artificial gastric juice might be due to the acid present. The activity of the amylolytic enzymes has always been tested first with starch paste, and that of the gastric extract with fibrin. Boiled controls have been employed in every instance, and all trials have been made in duplicate.

Tests for reducing sugar have been conducted in the following manner: At the end of 24 hours the solutions were evaporated to thick syrups on the water bath, to free from toluene and to concentrate so that the undigested hemicelluloses could be readily precipitated by absolute alcohol. The alcoholic extracts were filtered off and evaporated to dryness; the residues were taken up in a few drops of water and tested for sugar with Fehling's solution. The results of all digestion trials are shown in the table on opposite page.

PARENTERAL INJECTIONS.

Methods and Technique.

Small dogs were used for all injections, after a confinement in cages long enough to obtain samples of normal urine. The carbohydrates employed in these experiments were preparations of dulse,¹ Irish moss,² salep,³ and sinistrin.⁴ They were introduced *subcutaneously*, by means

¹Cf. p. 303.

²Cf. p. 308.

³Cf. p. 312.

⁴Cf. p. 315.

ENZYMES.

HEMICELLULOSE.

CLASS.	SOURCE.	SALIVA.	MALT DIASTASE.	"TAKA" ¹ DIASTASE.	PANCREATIC EXTRACT.	PANCREATIC JUICE.	INTESTINAL EXTRACT.	GASTRIC EXTRACT.	0.2 PER CENT. HCl.
Pentosan.	Dulce	—	—	+	—	—	—	—	—
Pentosan.	Limu Lippoa	—	—	—	—	—	—	—	—
Galactan.	Irish Moss	—	—	—	—	—	—	—	—
Galactan.	Limu Manauca	—	—	—	—	—	—	+	—
Galactan.	Limu Huna	—	—	—	—	—	—	—	—
Galactan.	Limu Akiaki	—	—	—	—	—	—	—	—
Galactan.	Limu Uaualoli	—	—	+	—	—	—	+	—
Galactan.	Limu Kohu	—	—	—	—	—	—	—	—
Galactan.	Slippery Elm	—	—	—	—	—	—	—	—
Mannan.	Salap	—	—	(+ in 3 days)	—	—	—	—	—
Levulan.	Sinistrin	—	—	+	—	—	—	+	+

(+ in 3 days)
+ (½ hr. at 37° C.)

of a syringe, or *intra-peritoneally*, by means of a needle and burette with pressure-bulb attached, always under aseptic conditions. After receiving injections, the animals were replaced in cages, and the urine collected under toluene. The excess of toluene was removed, at the time of examination, by means of a separatory funnel, and the urine measured, filtered, and tested for reducing substances with Fehling's solution.

Qualitative tests for the carbohydrates were made in the following manner: (1) for dulse and salep, by boiling a few drops of urine with Fehling's solution, from which these hemicelluloses were precipitated in fine white flocks, even if only traces were present; (2) for Irish moss, by the reduction of Fehling's solution after hydrolysis of the urine with dilute hydrochloric acid;¹ (3) for sinistrin, by the marked increase in the levo-rotation of the urine.

Isolation of the carbohydrates was accomplished by freeing the urine from inorganic salts with lead acetate, removing the excess of lead with hydrogen sulphide, and concentrating the salt-free solutions to a small volume. Dulse and Irish moss were then precipitated with absolute alcohol; salep with alcohol or Fehling's solution; sinistrin with milk of lime, being freed from its calcium compound by the method used in its preparation.²

These substances were identified as carbohydrates, by their yielding reducing sugar on hydrolysis; salep and sinistrin were further identified by their levo-rotation, Irish moss by testing for mucic acid, and dulse by testing for furfurol.

Quantitative determinations of dulse, salep and sinistrin were made by polariscopic examination in a 200 mm. tube, all samples of urine being clarified with equal volumes of alumina cream. A satisfactory quantitative method for the determination of Irish moss was not developed. It proved impossible to estimate any of these carbohydrates quantitatively by the method of acid hydrolysis. In some instances, especially with Irish moss, a trace of reduction was obtained, but in most cases, the results were negative, although the hemicellulose was known to be present.³

¹Trial was made of Bauer's method (*Zeitschrift für physiologische Chemie*, 51, p. 158, 1907) of determining galactose in urine as mucic acid, by concentrating 100 cc. of urine with 25-35 cc. of concentrated nitric acid (sp. gr. 1.4) to a volume of 20 cc., but owing probably to the low percentage of galactose from the small amount of Irish moss present, this test was unsatisfactory.

²Cf. p. 315.

³Samples were removed and tested every half hour for 2½ hours. At the end of 1 hour they were usually neutral, or slightly alkaline in reaction. Addition of suf-

INJECTIONS OF DULSE.

1. *Subcutaneous.*

A dog weighing 11 kg. received 60 cc. of a dulse solution containing 0.9 grams of pure substance. No reduction of Fehling's solution was observed at any time. The time and rate of dulse excretion are shown in the following table:

Examination of Urine.

TIME.	VOLUME.	ROTATION.	ESTIMATED EXCRETION OF DULSE.*
	cc.		Grams.
February 1, 12:30 P.M.....		-0.14°†	
February 1, 1 P.M.....	Injection		
February 2, 10 A.M.....	226	- 0.62°	0.61
February 3, 10 A.M.....	250	- 0.55°	0.57
February 4, 10 A.M.....	150	- 0.41°	0.21
February 5, 10 A.M.....	210	- 0.34°	0.21
February 6, 10 A.M.....	310	- 0.28°	0.04
February 7, 10 A.M.....		- 0.20°	
		Total.....	1.64

2. *Intraperitoneal.*

The same dog received in this experiment 75.6 cc. of a dulse solution containing 1.4 grams of pure substance. No reduction of Fehling's solution was observed before or after the injection. The time and rate of dulse excretion are shown in the following table:

Examination of Urine.

TIME.	VOLUME.	ROTATION.	ESTIMATED EXCRETION OF DULSE.*
	cc.		Grams.
December 3, 2 P.M.....		-0.14°†	
December 3, 3 P.M.....	Injection		
December 4, 10 A.M.....	133	- 0.62°	0.36
December 5, 10 A.M.....	200	- 0.52°	0.42
December 5, 12 M.....	115	- 0.28°	0.05
December 6 and 7.....	383	- 0.48°	0.69
December 8, 10 A.M.....	520	- 0.28	0.24
December 9, 10 A.M.....	350	- 0.20	
		Total.....	1.76

cient hydrochloric acid to make the strength 2 per cent caused no subsequent production of sugar.

* All readings have been taken on the Ventzke scale, and calculated as angular degrees.

† Estimating normal rotation of urine as -0.17° (average).

In both these experiments, the presence of dulse was readily detected by Fehling's solution in every urine which showed a high rotation. From the samples of the first 48 hours after injection, a considerable amount was isolated and identified as carbohydrate. It is evident that the excretion of this pentose-carbohydrate is gradual, commencing soon after the injection, and continuing from four to five days. While any quantitative estimate of the amount excreted, based on the changes in rotation, is subject to a high percentage of error, owing to normal fluctuations in the rotation of the urine, as well as to analytical discrepancies unavoidable in dealing with solutions containing only minute quantities of the substance under investigation, it is evident that most of the dulse must have been excreted, and that, too, without any essential change in character.

INJECTIONS OF IRISH MOSS.

1. *Subcutaneous.*

A dog weighing 9.4 kg. received 100 cc. of Irish moss solution, containing 1.5 grams of dry substance. No reducing substance occurred in the urine. Changes in rotation, due to the injection, are shown in the following table:

Examination of Urine.

TIME.	VOLUME.	ROTATION.	IRISH MOSS.
	<i>cc.</i>		
May 18, 9 A.M.		-0.04°	—
May 18, 4 P.M.	Injection		
May 19, 9 A.M.	128	+ 0.34°	—
May 20, 9 A.M.	226	+ 0.06°	—
May 21, 11 A.M.	330	- 0.20°	—
May 22, 9 A.M.	370	- 0.14°	—

Tests for Irish moss on May 19th were negative, but on May 20th-22nd they were faintly positive. The experiment was discontinued at this point. The injection was not very well borne, the dog remaining lethargic throughout the period.

2. *Intraperitoneal.*

Experiment A. A dog weighing 10 kg. received 160 cc. of an Irish moss solution containing 1.3 grams air dry material. Examination

for the presence of carbohydrate was made by testing the urine for reducing substances, before and after hydrolysis. The results are shown in the following table:

Examination of Urine.

TIME.	VOLUME.	REDUCTION OF FEHLING'S SOLUTION.	
		Before Hydrolysis.	After Hydrolysis.
	cc.		
October 13, 11 A.M.		—	—
October 13, 12:30 P.M.	Injection		
October 13, 2 P.M.	27	—	—
October 13, 5 P.M.	60	—	+
October 14, 9 A.M.	450	—	+
October 15, 5 P.M.	45	—	—
October 16, 9:30 A.M.	—	—	—

The urine before the injection showed a rotation of -0.14° , a sample of the mixed urines of October 13, 5 P.M., and October 14, 9 A.M., showed a rotation of -0.034° , the diminished levo-rotation undoubtedly due to the presence of this dextro-rotatory carbohydrate. On hydrolysis, 50 cc. of this mixed sample yielded sugar equivalent to 0.035 grams of dextrose (by Allihn's method). From the remainder of this sample, Irish moss carbohydrate was isolated; it formed a grayish-white powder, swelling in water, and yielding mucic acid on oxidation with nitric acid.

Experiment B. A dog weighing 9 kg. received intraperitoneally 100 cc. of a 2 per cent solution of Irish moss preparation. Examination for carbohydrate was made as in the preceding experiments. The results appear in the following table:

Examination of Urine.

TIME.	VOLUME.	REDUCTION OF FEHLING'S SOLUTION.	
		Before Hydrolysis.	After Hydrolysis.
	cc.		
October 30, 1 P.M.		—	—
October 30, 2:30 P.M.	Injection	—	—
October 31, 9 A.M.	250	—	—
November 1, 10 A.M.	200	—	+
November 2, 10 A.M.	115	—	—

Irish moss was isolated and identified in the urine of November 1st.

INJECTIONS OF SALEP.

1. *Subcutaneous.*

A dog weighing 7.2 kg. received 56 cc. of salep solution, containing 0.75 grams of pure mannan. No reducing substance was found in the urine. The changes in rotation, due to salep, are shown in the following table:

Examination of Urine.

TIME.	VOLUME.	ROTATION.	ESTIMATION OF AMOUNT OF SALEP EXCRETED.
	cc.		Grams.
May 17,.....	Injection	- 0.17°	
May 18, 3:30 P.M.....			
May 19, 9 A.M.....			
May 20, 9 A.M.....	138	- 0.27°	0.3
May 21, 9 A.M.....	132	- 0.27°	0.3
May 22, 9 A.M.....	114	- 0.20°	0.04
May 22, 5 P.M.....	127	- 0.14°	

Salep was isolated and identified in the urines of May 20, 21, and 22.

2. *Intraperitoneal.*

Experiment A. A dog weighing 7 kg. received 68 cc. of salep solution, containing 1.2 grams of air dry mannan. No reducing substance was present in the urine at any time. Tests for the presence of salep by means of Fehling's solution, gave the following results:

Examination of Urine.

TIME.	VOLUME.	SALEP PRESENT.
	cc.	
October 21, 12 M.....		
October 21, 2:30 P.M.....	Injection	
October 22, 9 A.M.....	125	+
October 23, 9 A.M.....	190	+
October 24, 9 A.M.....	140	-

The salep was easily isolated and identified in the urine of October 22 and 23, the sugar obtained on hydrolysis being equivalent to 0.33 grams salep.

Experiment B. A dog weighing 9.2 kg. received 80 cc. of salep so-

lution, containing 1.4 grams of air dry substance. No reducing substance was detected in any of the urines. Tests for salep with Fehling's solution gave the following results:

Examination of Urine.

TIME.	VOLUME.	SALEP PRESENT.
	cc.	
October 24, 11 A.M.		
October 24, 12 M.	Injection	
October 25, 12 M.	155	+
October 26, 10 A.M.	180	+
October 27, 10 A.M.	180	+
October 28, 10 A.M.		—

From the urine of October 25, salep was isolated, which yielded on hydrolysis 0.39 grams reducing sugar as dextrose; it was also isolated from the urines of the next two days, but was not estimated quantitatively.

Experiment C. A dog weighing 9.2 kg. received 90 cc. of salep solution, containing 1.8 grams of pure mannan. No reduction of Fehling's solution occurred with any of the samples. Tests for salep with Fehling's solution gave the following results:

Examination of Urine.

TIME.	VOLUME.	ROTATION.	SALEP PRESENT.
	cc.		
December 2, 10 A.M.		-0.17°	
December 2, 2:30 P.M.	Injection		
December 3, 10 A.M.	960		+
December 4, 10 A.M.	234	-0.41°	+(0.6 gm.)
December 5, 10 A.M.	520	-0.27°	+(0.5 gm.)

Unfortunately this experiment was unavoidably interrupted at this point. The salep was precipitated from 50 cc. of the urine for December 3, hydrolyzed, and sugar determined gravimetrically as dextrose, from which the total amount of salep in this day's urine was calculated as 0.67 gram. Salep determined in the same way on December 4, showed an elimination of 0.18 gram; hence 0.85 gram was actually recovered in these two days. The influence of the levorotatory carbohydrate on the rotation of the urine was marked.

Experiment D. A dog weighing 6.4 kg. received 98 cc. of salep solution containing 1 gram of pure mannan. No reduction of Fehling's solution was observed throughout the experiment. The changes in rotation due to the salep are shown in the following table:

Examination of Urine.

TIME.	VOLUME.	ROTATION.	SALEP PRECIPITATED BY FEHLING'S SOLUTION.
	cc.		
January 31.....	116	- 0.41°	
February 1.....	Injection		
February 2.....	152	- 0.41°	—
February 3.....	238	- 0.13°	+
February 4.....	154	- 0.13°	—
February 5.....	137	- 0.20°	—

The results in this experiment are very puzzling. The normal rotation was high (-0.41°) for several weeks before this experiment but fairly constant, averaging -0.44° . If salep were excreted as mannan, the levo-rotation should have increased, yet it was decidedly low on a day when salep was shown to be present, and also on a day when none could be detected. The absence of any positive tests for sugar, excluded the idea that the salep was being excreted in this form, but finally a sample of February 4, was tested with yeast, and marked fermentation observed. Unfortunately, this was after all the other samples had been discarded, hence no further tests could be made.

Experiment E. A dog weighting 9.8 kg. received intraperitoneally 97.5 cc. of salep solution containing 1.3 grams pure mannan. No reduction of Fehling's solution was observed. The changes in rotation are shown in the first table on the next page.

Salep was isolated and identified as carbohydrate, in the urines of May 19, 20, and 21, although the amount in the last two days was apparently too small to be detected by any change in the rotation.

INJECTIONS OF SINISTRIN.

I. Subcutaneous.

A dog weighing 6.5 kg. received 49 cc. of sinistrin solution, containing 3.3 grams pure substance. This solution showed a rotation of

Examination of Urine.

TIME.	VOLUME.	ROTATION.	ESTIMATION OF AMOUNT OF SALEP EXCRETED.
	cc.		Grams.
May 17, 10 A.M.		- 0.14°	
May 18, 10 A.M.		- 0.14°	
May 18, 3 P.M.	Injection		
May 19, 9 A.M.	165	- 0.34°	0.4
May 20, 9 A.M.	250	- 0.14°	Salep present—precipitated by Fehling's Solution.
May 21, 11 A.M.	405	- 0.14°	Salep present.
May 22, 9 A.M.	200	- 0.14°	No Salep present.

-3.88° in a 200 mm. tube. The urine contained no reducing substance at any time. The changes in rotation, due to sinistrin injection, are shown in the following table:

Examination of Urine.

TIME.	VOLUME.	ROTATION.	ESTIMATION OF AMOUNT OF SINISTRIN EXCRETED.*
	cc.		Grams.
January 15, 12 M.		- 0.41°	
January 15, 2:30 P.M.	Injection		
January 16.	260	- 0.97°	2.5
January 17 and 18.	165	- 0.41°	
January 19.	60	- 0.41°	
January 20.	108	- 0.47°	

* Calculating for sinistrin $[\alpha]_D = -29.1^\circ$.

2. Intra-peritoneal.

Experiment A. A dog weighing 6.5 kg. received 110 cc. of sinistrin solution, containing 2 grams pure substance. This solution showed a rotation of -1.18° in a 200 mm. tube. No reducing substance was found in the urines examined. The changes in rotation, due to sinistrin injection, are shown in the following table:

Examination of Urine.

TIME.	VOLUME.	ROTATION.	ESTIMATION OF AMOUNT OF SINISTRIN EXCRETED.*
	cc.		Grams.
January 11, 10:30 A.M.		- 0.48°	
January 11, 3 P.M.	Injection		
January 12, 9:30 A.M.	88	- 2.04°	2.7
January 13, 9:30 A.M.	127	- 0.48°	
January 14, 9:30 A.M.	116	- 0.48°	

* Calculating for sinistrin $[\alpha]_D = -29.1^\circ$.

Experiment B. A dog weighing 4.6 kg. received 108 cc. of sinistrin solution, containing 2.3 grams pure substance. The rotation of this solution was -1.38° in a 200 mm. tube. No reducing substance was detected in the urine at any time. The changes in rotation are shown in the following table:

Examination of Urine.

TIME.	VOLUME.	ROTATION.	ESTIMATION OF AMOUNT OF SINISTRIN EXCRETED.*
	cc.		Grams.
January 26.		- 0.14°	
January 27, 9:30 A.M.	Injection		
January 27, 5:P.M.	148	- 1.38°	2.1
January 28, 9:AM.	95	- 0.41°	0.4
January 29, 9:A.M.	155	- 0.14°	

* Calculating for sinistrin $[\alpha]_D = -29.1^\circ$.

In all these experiments, the sinistrin was isolated and identified as a levo-rotatory carbohydrate, yielding reducing sugar on hydrolysis. It was apparently excreted quantitatively in every case.

FEEDING EXPERIMENTS.

Methods and Technique.

Feeding experiments were conducted with dogs and human subjects, under conditions as nearly normal as possible. The *dogs* were kept in metal cages, arranged for the separate collection of urine and faeces. They were fed once a day, on a uniform weight diet, consisting of chopped lean meat, lard, and cracker meal, in suitable portions

and amounts to maintain a constant body weight. The carbohydrate under investigation was dissolved or suspended in water, and mixed with this basal ration. In the earlier experiments the periods were divided as follows: Fore = 3 days on the basal ration; mid = 3 days in which some preparation was added, the amount being the same each day; after = 3 days like the fore period. Separation of the periods in the faeces was accomplished by marking with soot or carmine capsules. In all later experiments, two days constituted the fore period, and a day on the normal diet was included at the beginning and end of the mid period, making thus four days, to insure against any of the material under investigation being carried into the faeces of the after period.

In several cases, the presence or absence of galactans or mannans in the faeces has been verified by testing the hydrolyzed material for mucic acid or mannose-hydrazone.

For analysis, the faeces, collected and weighed, were rubbed to a thin mud with alcohol, dried to constant weight on a water bath, weighed air dry, and ground finely in a coffee mill. The portions constituting each period were thoroughly mixed, and from 2 to 5 grams taken for hydrolysis, according to the yield of carbohydrate anticipated. The samples were boiled on a reflex condenser with 100 cc. of 2 per cent hydrochloric acid, for two hours; or longer if thought to contain a carbohydrate which previous analysis¹ had shown to require more time for complete hydrolysis.

The products of hydrolysis, cooled and neutralized, were made up to 250 cc. and sugar determined as dextrose by Allihn's gravimetric method. It was found that the copper reduction was often very incomplete, and that much more satisfactory results came from clarifying the solutions with charcoal after making up to volume. Not only were duplicate analyses in closer agreement, but in some cases the yield of cupric oxide was two or three times greater than before this treatment. Owing to the complexity and diversity of the products of hydrolysis, results are at best only approximate.

In experiments with dulse, the pentosans were determined by the phloroglucin method.²

The *human subjects* were healthy, active young women. Their diet was not weighed, but was kept as uniform as possible. All cel-

¹ Cf. table, p. 317.

² Cf. Official and Provisional Methods of Analysis, Bulletin No. 107 (1907), Bureau of Chemistry, United States Department of Agriculture.

lulose-containing foods, such as nuts, fruits, green vegetables, peas and beans, coarse bread and cereals, were carefully avoided; so that the carbohydrates were limited almost entirely to bread and crackers made from fine white flour, a small quantity of potato, and sugar. To this diet the gelatinizing carbohydrates were added in the form of blanc mange or jelly; dulse was dissolved in some beverage, and the insoluble preparations boiled half an hour in a little water and eaten as a vegetable, seasoned with salt, butter, and vinegar. The blanc manges or jellies made from the Hawaiian seaweed preparations were equally attractive in texture and flavor with those made from Irish moss.

Periods were marked, and the analyses of faeces conducted in the manner already described for the experiments with dogs.

The Digestibility of Pentosans.

Four preparations were fed, Dulse,¹ Limu Eleele,² Limu Lipoa,² and Limu Pahapaha,³ without production of unpleasant symptoms in any case. The results of all trials are shown in the tables on the following pages.

¹ Cf. p. 303.

² Cf. p. 307.

³ Cf. p- 308.

Dulse.

SERIES.	NO.	SUBJECT.	WEIGHT.	PERIOD.	DIET.	COMPOSITION OF FAECES.					
						WEIGHT MOIST.	WEIGHT AIR DRY.	PENTOSAN. (As Phloroglucid).	DULSE FED (As Pento-sen).	DULSE RECOVERED.	
			Kg.			Grams.	Grams.	Per cent.	Grams.	Per cent.	
A	1	Dog III	7	{ Fore = 3 days Mid = 3 days After = 3 days { Fore = 2 days	Meat, 150 gms. Lard, 30 gms. Cracker meal, 75 gms. Same + 45 gms. dulse preparation Same as Fore Period Meat, 150 gms.	13.4	28.3	29.6	32.5	20	
						20.0	8.0	1.6	0.31		
						13.8	1.1	0.15			
A	2	Dog I	9.2	{ Mid = 4 days After = 2 days { Fore = 2 days Mid = 4 days	Lard, 30 gms. Cracker meal, 30 gms. Same + 20 gms. dulse preparation Same as Fore Period Cellulose-free Same + 10 gms. dulse preparation	26.6	11.8	1.8	0.2	34	
						62.6	1.8	0.5	5.3		
						32.8	2.4	0.8	7.2		
A	3	Z (Woman)	50	{ After = 2 days { Fore = 2 days Mid = 4 days	Same as Fore Period Cellulose-free Same + 10 gms. dulse preparation	243.6	209.1	2.2	1.2		
						87.7	2.7	1.2	0.8		
						70.0	2.4	1.5	7.2		
A	4	P (Woman)	56	{ After = 2 days { Fore = 2 days Mid = 4 days	Same + 10 gms. dulse preparation Same as Fore Period	191.1	150.4	2.4	1.2		
						48.6	2.4	0.9	7.2		
						37.2	2.4	0.9	7.2		

Limu Elecle (Enteromorpha intestinalis).

COMPOSITION OF FAECES.

SERIES.	NO.	SUBJECT.	WEIGHT.	PERIOD.	DIET.	WEIGHT MOIST.	WEIGHT AIR DRY.	PENTOSAN (As Dextrose).		LIMU FED (As Dextrose).	LIMU RE- COVERED.
								Grams.	Per cent.		
A	5	Dog V	11.2	Fore = 2 days	Meat, 200 gms.	34.0	15.5	4.9	0.7	3.6	50
					Lard, 25 gms.						
					Cracker meal, 30 gms.						
					Same + 20 gms. powdered Limu Elecle boiled $\frac{1}{2}$ hr.						
A	6	Dog IV	13.6	Fore = 2 days	Meat, 250 gms.	24.6	14.5	6.7	0.9	3.6	50
					Lard, 40 gms.						
					Cracker meal, 30 gms.						
					Same + 30 gms. powdered Limu Elecle boiled $\frac{1}{2}$ hr.						
A	7	Z (Woman)	52	Fore = 2 days	Meat, 250 gms.	300.3	89.2	5.4	4.6	5.4	31
					Lard, 40 gms.						
					Cracker meal, 30 gms.						
					Same + 30 gms. powdered Limu Elecle boiled $\frac{1}{2}$ hr.						
						65.7	22.5	4.8	1.0		

Limu Pahapaha (Uba Lactuca, etc.).

SERIES.	NO.	SUBJECT.	WEIGHT.	PERIOD.	DIET.	COMPOSITION OF FAECES.					
						WEIGHT MOIST.	WEIGHT AIR DRY.	PENTOSAN (As Dextrose). (As Dextrose). RECOVERED.	LIMU FED (As Dextrose). RECOVERED.		
			Kg.			Grams.	Grams.	Per cent.	Grams.	Per cent.	
A	8	Z (Woman)	52	{ Fore = 2 days Mid = 4 days* After = 2 days	Cellulose-free	65.7	22.5	4.8	1.0		
					Same + 30 gms. Limu Pahapaha, boiled ½ hr.	95.4	46.4	8.1	3.8	1.0	66
					Same as Fore Period	193.4	26.8	8.2	2.1		

* Some intestinal fermentation was noticed on Limu days.

Limu Lipoa (Haliscris Pardalis)

A	9	Dog V	11.2	{ Fore = 2 days Mid = 4 days After = 2 days	Meat, 200 gms. Lard, 25 gms.	35.8	19.4	5.5	1.0		
					Cracker meal, 30 gms. Same + 30 gms. Limu Lipoa boiled ½ hr.	184.0	61.4	8.6	5.5	4.4	84
					Same as Fore Period	24.2	14.5	6.7	0.9		

The coefficients of digestibility of the pentosan preparations, as determined in the usual way from the preceding experiments, are set forth in the following table:

SERIES A. EXPERIMENT NO.	PENTOSAN.	COEFFICIENT OF DIGESTIBILITY.	
		For the Dog.	For Man.
1	Dulse	80	
2	Dulse	66	
3	Dulse		100
4	Dulse		100
5	Limu Eleele	50	
6	Limu Eleele	20	
7	Limu Eleele		69
8	Limu Pahapaha		34
9	Limu Lipoa	16	

It is evident from these figures, that pentosans in soluble form disappear from the alimentary tract of dogs to a very considerable extent (average 73 per cent), and that small quantities, ingested by man, do not reappear in the faeces. The insoluble limu preparations appear much more indigestible, an average of 28 per cent being digested by dogs, and 51 per cent by man.

It must be borne in mind, in interpreting the results of these metabolism experiments, that they are at best only approximate. The difficulty of strict separation of the faeces, the fact that the human subjects were not kept on a uniform weighed diet, and the errors unavoidably introduced by determining many different kinds of sugar as dextrose, make all of the figures given as "coefficients of digestibility," in this and succeeding sections, comparative rather than absolute.

The Digestibility of Galactans.

In these experiments, preparations of the water extracts of Irish moss, Limu Manauea, Limu Huna and Limu Akiaki have been fed, without any disagreeable symptoms. The results are given in the tables which follow:

Irish Moss (Chondrus Crispus).

SE-RIES	NO.	SUBJECT.	WEIGHT.	PERIOD.	DIET.	COMPOSITION OF FAECES.				
						WEIGHT MOIST.	WEIGHT AIR DRY.	CARBOHYDRATES (As Dextrose).	LIMU FED (As Dex-trose).	LIMU RECOVERED.
			Kg.			Grams.	Grams.	Per cent.	Grams.	Per cent.
B	1	Dog I	8.4	Fore = 3 days	Meat, 200 gms. Lard, 40 gms.	29.1	9.4	2.7		
				Mid = 2 days	Cracker meal, 100 gms.	42.5*	25.5	10.8	9.8	54
				After = 3 days	Same + 20.3 gms. Irish moss preparation	15.6	19.0	2.9		
				Fore = 3 days	Same as Fore Period					
B	2	Dog II	10.0	Fore = 3 days	Meat, 200 gms. Lard, 40 gms.	16.9	8.6	1.4		
				Mid = 3 days	Cracker meal, 100 gms.	67.7*	26.4	17.8	21.8	80
				After = 3 days	Same + 45 gms. Irish moss preparation	21.0	6.0	1.3		
				Fore = 2 days	Cellulose-free	57.9	6.4	0.8		
B	3	X (Woman)	42.0	Mid = 4 days	Same + 30 gms. Irish moss preparation	458.9	14.8	14.6	14.5	89
				After = 2 days	Same as Fore Period	150.7	9.1	3.2		
				Fore = 2 days	Cellulose-free	115.7	5.7	2.0		
				Mid = 4 days	Same + 30 gms. Irish moss preparation	367.6	21.0	20.0	14.5	100
B	4	Z (Woman)	52	After = 2 days	Same as Fore Period	133.6	9.6	1.3		

* Rich yield of mucic acid from faeces of this period.

† Mucic acid obtained from these faeces.

‡ Ten grams faeces yielded 0.26 grams mucic acid.

Limu Manauca (Gracilaria Coronopifolia).

COMPOSITION OF FAECES.

SERIES.	NO.	SUBJECT.	WEIGHT.	PERIOD.	DIET.	WEIGHT MOIST.	WEIGHT AIR DRY.	CARBOHYDRATES (As Dextrose).		LIMU FED (As Dex- trose).	
								Grams.	Per cent.	Grams.	Per cent.
			Kg.								
B	5	Dog IV	13.6	Fore = 2 days Mid = 4 days After = 2 days Fore = 2 days	Meat, 250 gms. Lard, 40 gms. Cracker meal, 40 gms. Same + 14 gms. Limu Ma- nauca preparation Same as Fore Period Meat, 200 gms. Lard, 25 gms.	30.3	14.3	8.3	1.2		
						94.6	31.0	18.0	5.6	6.2	45
						27.3	17.3	9.0	1.6		
B	6	Dog V	11.2	Mid = 4 days After = 2 days Fore = 2 days Mid = 5 days	Cracker meal, 30 gms. Same + 10 gms. Limu Ma- nauca preparation Same as Fore Period. Cellulose-free	34.0	13.5	4.8	0.7		
						95.7	34.7	11.5	4.0	4.4	68
						35.8	19.4	5.4	1.0		
						158.9	40.0	6.2	2.4		
B	7	P (Woman)	56	After = 2 days Fore = 2 days Mid = 5 days	Same + 15 gms. Limu Ma- nauca preparation Same as Fore Period Cellulose-free	297.7	83.9	11.1	9.3	6.7	70
						150.4	37.2	3.8	1.4		
						150.9	41.7	4.3	1.8		
B	8	Z (Woman)	52	Mid = 4 days After = 2 days	Same + 10 gms. Limu Ma- nauca preparation Same + 14 gms. Limu Ma- nauca preparation Same as Fore Period	536.6	99.7	7.8	7.8	4.4	100
						242.5	67.9	7.1	4.8	6.2	40
						90.8	24.9	6.4	1.6		

Limu Huna (Hypnea nidifica).

COMPOSITION OF FAECES.

RE- LES.	NO.	SUBJECT.	WEIGHT.	PERIOD.	DIET.	WEIGHT MOIST.	WEIGHT AIR DRY.	CARBOHYDRATES (As Dextrose).		LIMU FED (As Dex- trose).	LIMU RECOVERED.
								Grams.	Per cent.		
			Kg.								
B	9	Dog IV	13.6	Fore = 2 days Mid = 4 days After = 2 days Fore = 2 days	Meat, 250 gms. Lard, 40 gms. Cracker meal, 30 gms. Same + 20 gms. Limu Huna preparation Same as Fore Period Meat, 200 gms. Lard, 25 gms.	30.3	14.3	8.3	1.2		
						126.1	53.9	16.1	8.6	11.6	60
						27.3	17.3	9.0	1.6		
B	10	Dog V	11.2	Mid = 4 days After = 2 days Fore = 2 days Mid = 5 days After = 2 days	Cracker meal, 30 gms. Same + 7 gms. Limu Huna preparation Same as Fore Period Cellulose-free Same + 10 gms. Huna prep- aration Same as Fore Period	35.8	19.4	5.4	1.0		
						57.8	40.5	7.7	3.1	4.0	17
						34.0	15.5	4.9	0.7		
						143.4	38.2	7.3	2.8		
B	11	X (Woman)	42	After = 2 days	Same as Fore Period	245.1	94.8	7.6	7.0	5.8	90
						135.7	23.7	9.9	2.3		

Limu Akiaki (Ahmfeldtia concinna).

B	12	B (Woman)	62	Fore = 2 days Mid = 4 days After = 2 days	Cellulose-free Same + 20 gms. Limu Akiaki preparation Same as Fore Period	147.8	24.5	6.0	1.6		
						451.1	72.2	8.3	6.0	7.2	40
						Not weighed	24.5	10.4	2.5		

The coefficients of digestibility of the galactan preparations are given in the following table:

SERIES B. EXPERIMENT NO.	GALACTAN.	COEFFICIENT OF DIGESTIBILITY.	
		For the Dog.	For Man.
		<i>Per cent.</i>	<i>Per cent.</i>
1	Irish Moss	46	
2	Irish Moss	20	
3	Irish Moss		11
4	Irish Moss		0
5	Limu Manauea	55	
6	Limu Manauea	12	
7	Limu Manauea		30
8	Limu Manauea		30 (av.)
9	Limu Huna	30 (20 gms. fed)	
10	Limu Huna	83 (7 gms. fed)	
11	Limu Huna		10
12	Limu Akiaki		60

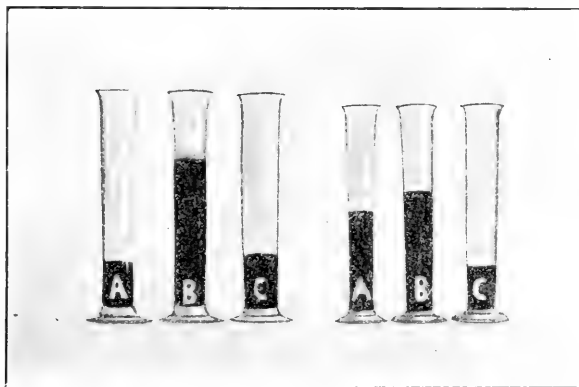
Although these preparations were administered in small quantities, under the most favorable conditions for digestion in, the only instance where the utilization in any degree approaches that of starch (Limu Huna), the quantity fed (7 grams) was so small that this experiment can hardly be taken as a criterion of digestibility. Exclusive of this experiment, the average of five trials with dogs is 32 per cent, while that of six trials with human subjects is 23 per cent. In both cases, the averages are lower than that of Lohrisch (194) for "soluble agar," 50 per cent.

Where the quantity of galactan fed was 10 or more grams, the influence on the character of the faeces was usually noticeable. The increase in bulk, after ingestion of 45 grams of Irish moss, is well illustrated in a photograph of the dried and ground faeces of the dogs used in experiments 1 and 2:¹

A represents the fore-period (3 days), B the mid-period, during which 15 grams of moss were ingested daily (3 days), and C the after-period (3 days). The separation of the faeces at the beginning of experiment 1 (on the right) was not very satisfactory. The dog had previously been fed bone-ash, and the marked faeces were undoubtedly contaminated with this, so that they appear unusually bulky. Experiment 2 is typical of the results obtained in most of the experiments

¹ Cf. p. 343.

with human subjects. In these, the undigested hemicelluloses gave frequently a peculiar, wax-like consistency, especially noticeable with Limu Huna in the experiment recorded,¹ and in another not reported, because the faeces for part of the time were lost. In the experiment with Limu Akiaki (No. 12),¹ the galactan was excreted after the first day's feeding, in a tough mass almost impossible to break up with a



EXP. 2

EXP. 1

I.

The Influence of Irish Moss upon the Mass of the Faeces.

- A. Fore Period: 3 Days on a Cellulose-free Diet.
- B. Mid Period: 3 Days on a Cellulose-free Diet to Which 15 grams of Irish Moss were Added Daily.
- C. After Period: 3 Days of a Cellulose-free Diet.

spatula. That of the second day was not excreted till the third day after feeding, the subject being inclined to constipation. It seems likely that the high coefficient of digestibility is due to this fact, or else to the method of determination, which is not altogether satisfactory, in view of the complexity of the products of hydrolysis, the danger of decomposing a part of the sugar from the easily inverted polysaccharides by the long boiling necessary for the more resistant, and the great difference in reducing power of the sugars so produced.

The Digestibility of Mannan.

In four experiments, the commercial salep powder (containing 19 per cent mannan and 26 per cent starch) was administered; in the others, pure mannan prepared from the Orchis tubers. The results of seven trials are tabulated on the following pages.

¹ Cf. p. 345.

Salep.

SÉ- RIES.	NO.	SUBJECT.	WEIGHT.	PERIOD.	DIET.	COMPOSITION OF FAECES					
						WEIGHT MOIST.	WEIGHT AIR DRY.	CARBOHYDRATES (As Dextrose).	SALEP FED (As Dex- trose).	SALEP RECOVERED.	Per cent.
						Grams.	Grams.	Per cent.	Grams.	Grams.	
			Kg.			Grams.	Grams.	Per cent.	Grams.	Per cent.	
C	1	Dog III	7	Fore = 3 days Mid = 3 days After = 3 days	Meat, 150 gms. Lard, 30 gms. Cracker meal, 75 gms. Same + 45 gms. Salep Powder Same as Fore Period Meat, 200 gms.	13.4	5.7	0.7	34.0	30	
						31.5	37.9	11.9			
						6.9	17.1	1.2			
C	2	Dog I	9.2	Fore = 3 days Mid = 3 days After = 3 days	Lard, 40 gms. Cracker meal, 75 gms. Same + 45 gms. Salep Powder Same as Fore Period Cellulose-free	29.1	9.4	2.7	34.0		
						30.2	18.3	5.5			
						21.8	15.0	3.2			
						115.7	5.7	2.0			
C	3	Z (Woman)	52	Mid = 4 days After = 2 days Fore = 2 days	Same + 30 gms. Salep Powder Same as Fore Period Cellulose-free	178.2*	8.6	4.5	22.7		
						150.5	4.3	2.1			
						57.9	6.4	0.8			
						265.5†	9.3	5.7			
C	4	X (Woman)	42	After = 2 days Mid = 4 days After = 2 days	Same + 30 gms. Salep Powder Same as Fore Period	262.3	6.4	3.6	22.7	6	
						57.1					

* Tests for mannose-hydrazone in hydrolyzed faeces were negative.

† Tests for mannose-hydrazone were negative.

Salep.

COMPOSITION OF FAECES

SERIES.	NO.	SUBJECT.	WEIGHT.	PERIOD.	DIET.	WEIGHT MOIST.	WEIGHT AIR DRY.	CARBOHYDRATES (As Dextrose).			SALEP FED (As Dextrose).		SALEP RECOVERED.	
								Per cent.	Grams.	Grams.	Grams.	Per cent.		
			Kg.											
C	5	Dog I	9.2	Fore = 2 days Mid = 3 days	Meat, 150 gms. Lard, 30 gms. Cracker meal, 30 gms. Same + 10 gms. Salep-Man- nan	11.8	32.3*	8.4	1.0	9.8	9.0	90		
								6.2	0.7	0.7				
								5.4	1.5	1.5				
C	6	Z (Woman)	52	After = 2 days Fore = 2 days Mid = 4 days	Same as Fore Period Cellulose-free Same + 20 gms. Salep-Man- nan	62.6	243.5†	6.0	4.2	2.3	18.0			
								3.9	2.3	2.3				
								6.3	2.5	2.5				
C	7	P (Woman)	56	After = 2 days Fore = 2 days Mid = 4 days After = 2 days	Same + 20 gms. Salep-Man- nan Same as Fore Period	173.2†	42.6	7.0	3.0	3.8	18.0			
								3.8	1.4	1.4				

* A large yield of mannose-hydrazone from hydrolyzed faeces.

† No mannose-hydrazone obtainable from hydrolyzed faeces.

The coefficients of digestibility of the salep preparations are shown in the following table:

SERIES C. EXPERIMENT NO.	MANNAN.	COEFFICIENT OF DIGESTIBILITY.	
		For the Dog.	For Man.
		<i>Per cent</i>	<i>Per cent</i>
1	Salep Powder	70	
2	Salep Powder	100	
3	Salep Powder		100
4	Salep Powder		94
5	Salep Mannan	10	
6			100
7			100

Thus we see that in every case, except that in which a dog received, in one day, 10 grams of pure mannan, the greater portion of the salep fed was digested, the coefficient of salep powder for dogs averaging 85 per cent, and for man, 97 per cent; while that of pure mannan for man is 100 per cent, in spite of the fact that it is not attacked by digestive enzymes!

The contrast between the volume of faeces produced when a galactan such as Irish moss was fed, and that when a more digestible hemicellulose was given, is shown in the photograph of the faeces from experiments Nos. 1 and 2 of Series C,¹ on the next page, in which A represents the fore-period, B the mid-period, and C the after-period, each period being three days in duration. The group on the right represents experiment No. 1, in which 70 per cent of the hemicellulose and starch of the salep powder was digested, and that on the left, experiment No. 2 in which apparently all of these were digested.

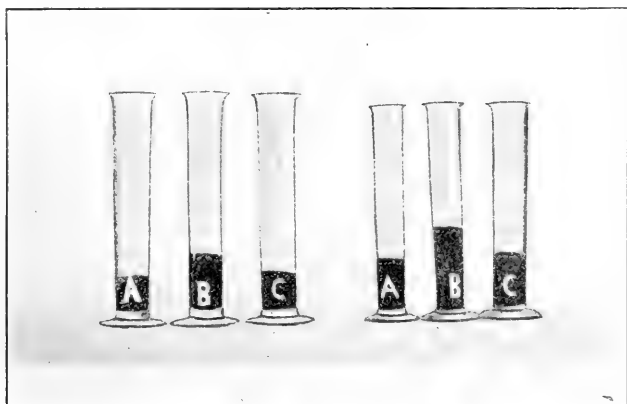
DISCUSSION AND SUMMARY.

A glance at the table on page 327 clearly shows that none of the hemicelluloses under consideration are readily attacked by the ordinary animal or vegetable enzymes. The results are for the most part entirely negative. Even where there has been hydrolysis with 0.2 per cent hydrochloric acid, the amount of sugar produced in 24 hours was relatively small. The hydrolyzing action of the gastric juice is probably largely due to the presence of acid, although no comparison of the relative amounts of sugar produced by gastric juice or by

¹Cf. p. 348.

0.2 per cent acid alone has been made. It is noticeable that even the very soluble hemicellulose, sinistrin, which is so speedily hydrolyzed by acid (in $\frac{1}{2}$ hour at 37° C. with 0.2% hydrochloric acid) is not attacked by ordinary diastatic enzymes within 24 hours.

The parenteral introduction of these carbohydrates has resulted in their speedy and apparently complete elimination through the kidneys without any change in character. The carbohydrates prepared from Dulce, Irish Moss, Salep and Sinistrin have all been isolated and identified in the urine, after subcutaneous and intraperitoneal injections. These results are not surprising, in view of the commonly ac-



EXP.

EXP. 1

II.

The Influence of Salep upon the Mass of the Faeces.

- A. Fore Period: 3 Days on a Cellulose-free Diet.
- B. Mid Period: 3 Days on a Cellulose-free Diet to Which 15 grams of Salep Powder were Added Daily.
- C. After Period: 3 Days on a Cellulose-free Diet.

cepted fact that carbohydrates must be converted into monosaccharides before they can enter into the processes of intermediary metabolism.

Experimental evidence in support of this fact is given by such investigators as F. Voit¹ and Blumenthal,² who found that even disaccharides, as lactose and saccharose, were eliminated almost quanti-

¹Münchener medicinische Wochenschrift, 1896, p. 717; Deutsches Archiv für klinische Medicin, v. 58, p.521 (1897).

²Beitäge zur chemischen Physiologie, v. 6, p. 329 (1905).

tatively after subcutaneous injection in man and the rabbit; or as Mendel and Mitchell,¹ who have shown that polysaccharides like dextrin, soluble starch, glycogen, inulin, and isolichenin are recovered to a considerable extent in the urine, whether introduced subcutaneously, intraperitoneally, or intravenously.

In the present experiments, the dulse pentosan was the most slowly eliminated, being found in the urine four or five days after injection; Irish moss and salep were not detected after the third day; while sinistrin seemed to be all excreted within the first 24 hours.

The average coefficients of digestibility for the ten preparations which have formed the basis of the feeding experiments, are summarized in the following table:

Coefficients of Digestibility of Hemicelluloses.

HEMICELLULOSE.		SUBJECT OF EXPERIMENT.	
Class.	Source.	Dog.	Man.
		<i>Per cent.</i>	<i>Per cent.</i>
Pentosan.....	Dulse	73 (2 exp.)	100 (2 exp.)
Pentosan.....	Limu Eleele	35 (2 exp.)	9 (2 exp.)
Pentosan.....	Limu Pahapaha		34 (1 exp.)
Pentosan.....	Limu Lipoa	16 (1 exp.)	
Galactan.....	Irish Moss	33 (2 exp.)	6 (2 exp.)
Galactan.....	Limu Manauea	33 (2 exp.)	30 (3 exp.)
Galactan.....	Limu Huna	56 (2 exp.)	10 (1 exp.)
Galactan.....	Limu Akiaki		60 (1 exp.)*
Mannan.....	Salep Powder	85 (2 exp.)	97 (2 exp.)
	Salep Mannan	10 (1 exp.)	100 (2 exp.)

* Subject with chronic constipation.

That the low coefficients enumerated above are not due to inability of the various subjects to utilize carbohydrates, is shown by the following figures.

The coefficient of digestibility for cracker meal in the experiments on dogs, determined by taking the average of all the fore-periods of the feeding trials, in which five different dogs were used, was 99.0 per cent. This is much higher than London and Polowzowa's² coefficient for carbohydrate digestibility in dogs on a bread diet, 96 per cent.

¹ American Journal of Physiology, v. 14, p. 239 (1905).

² Zeitschrift für physiologische Chemie, 56, 513 (1908).

For the four women who were subjects of feeding experiments, the average daily amount of carbohydrate excreted in the faeces, on a cellulose-free diet, estimated as dextrose, by averaging the fore-periods of all trials, was 0.8 gram. The utilization of carbohydrates was therefore unusually good, since Atwater and Bryant's¹ coefficient of digestibility for such a diet is 98 per cent, and undoubtedly every one of these individuals consumed over 50 grams of carbohydrate per day. With the exception of the subject of a single experiment who had chronic constipation, these were all normal, healthy individuals, free from disturbances of the alimentary tract.

The three seaweeds fed *in toto*, Limu Eleele, Limu Pahapaha, and Limu Lipoa, show an average digestibility of 51 per cent. This is higher than that obtained in Professor Mendel's laboratory for uncooked *Cetraria islandica*² (average of three experiments, 15 per cent) and much lower than that reported by Oshima for dried marine algae³ (average 77 per cent).

In man, with the exception of dulse and salep, which almost entirely disappeared in the alimentary tract, the average digestibility of all preparations is only 34 per cent, a figure in contrast to those of Lohrlich (194), who finds cellulose and hemicellulose 50 per cent digestible. In dogs, the average of all preparations is 42 per cent.

Considering that the pentosan of dulse was in a form most favorable for digestion, the results with this hemicellulose are in harmony with those of König and Reinhardt (120) who reported 75 per cent of the pentosans as disappearing from the alimentary tract in man; and with the averages obtained by the various investigators on animals, which show these carbohydrates 40-70 per cent digestible in herbivora.⁴ It would be desirable to repeat the experiments with larger quantities, although the process of preparing the material is rather laborious. It must be borne in mind, that the dulse pentosan is not attacked by ordinary diastatic enzymes, but can be decomposed by soil and faecal bacteria; and although this decomposition did not occur readily in pure solutions of the carbohydrate, or even in a putrefying mixture, it still remains to be demonstrated whether the complete disappearance from the alimentary tract is not largely due to the more favorable conditions for bacterial activity within the

¹ Report Storr's Agricultural Experiment Station, 1899, p. 86.

² Cf. pp. 297-298.

³ Cf. p. 299.

⁴ Cf. pp. 274-275.

organism. While we have, in the case of herbivora, some convincing evidence that the pentosans are a true source of energy,¹ we have as yet no real grounds for this assumption in the case of man.

The insoluble pentosans of the Hawaiian algae are manifestly less digestible than the soluble forms. The coefficient of digestibility is approximately the same as Slowtzoff's (154) average for pure xylan in rabbits, 55 per cent. While it would be perhaps desirable to determine the pentosans directly by the furfural-phloroglucin method, rather than by estimation of sugar after acid hydrolysis, a trial with dulse by both methods gave practically identical results: hence, considering that the hemicelluloses of these algae are chiefly pentosans, it seems safe to assume that the results reported represent the amount of pentosan excreted, within the limits of error for all of the feeding experiments.

The galactans were all soluble, and were ingested in quantities not exceeding 15 grams per day, yet the coefficient of digestibility is lower than for any other hemicellulose group (26 per cent). The resistance of Irish moss is particularly striking, but is not surprising in view of its utter indifference to attacks of digestive enzymes or bacteria. Its influence on the character of the faeces was not so marked as that of Limu Huna, owing probably to a greater tendency to liquefy at body temperature. The latter would seem to be a very effective agent in constipation; a comparison of its efficiency with that of agar-agar would be extremely interesting. Saiki (205) found the coefficient of digestibility for agar (average of two experiments) 17 per cent.

In view of the negative results of digestions *in vitro* and of trials with bacteria, we can scarcely be surprised at the results of these metabolism experiments, especially as we recall that Lohrisch (57) found that his "soluble agar," already partially hydrolyzed, was only digestible to 50 per cent (average).

The mannans stand in striking contrast to the galactans. In the present studies, 99 per cent of the salep administered has been utilized, a result in accordance with Kano and Iishima's (255) coefficient of digestibility for the Japanese mannan, Konjaku, 82 per cent. Pure mannan fed to a dog, was excreted the succeeding day, seemingly unaltered, since it formed a semi-transparent gelatinous mass in the faeces, from which, later, a rich yield of mannose-hydrazone was obtained. The very different result with salep powder, of which 85 per cent was digested by dogs, may perhaps be accounted for by the

¹ Cf. Kellner, p. 274.

fact that it contained a high percentage of starch (26 per cent). The amount of undigested carbohydrate excreted in the faeces is in close agreement with the quantity of pure mannan ingested. However, as tests for mannose-hydrazone were negative in these cases, further experiments are necessary before an authoritative statement can be made in regard to this question.

It is manifestly possible for faecal and soil bacteria to produce sugar from mannan;¹ hence it is not unlikely that hemicelluloses of this group are inverted in the intestines through the activity of micro-organisms, and that the sugar so produced is absorbed and becomes a true source of energy for man, in spite of the resistance of mannans to the action of digestion enzymes. Further investigations to determine its exact nutritive value seem highly desirable.

In considering the proper place in the dietary for marine algae, lichens and similar substances, we must not disregard the possibility of their having a valuable function entirely aside from the question of energy production. As Oshima (15) points out, they may be valuable for their inorganic salts. The non-irritating, laxative properties of many species make them desirable adjuncts to the diet of persons with a tendency to constipation;² and even if they disappear, in marked degree, from the alimentary tract during the process of digestion, they may perhaps still play an important rôle as stimulants to intestinal activity, being in fact what Prausnitz³ calls "faeces-forming foods." An illustration of this effect is afforded by the experiments in which salep powder was fed to dogs.⁴ The periods were equal in length, and in one case (No. 2 in photograph) the utilization of carbohydrates was equally good for all three; yet in the mid-period there is a decided increase in the bulk and weight⁵ of the faeces, not more than 1 gram of which is by any possibility attributable to the cellulose of the salep powder, and in the other experiment, the increased amount of faeces cannot be wholly accounted for by the amount of undigested carbohydrate present.

Mendel (196) has already sounded a warning against the hasty assumption that every carbohydrate, by virtue of its ultimate chemical composition, stands in the category of true nutrients for the human organism. The results of the present investigations emphasize the

¹ Cf. Sawamura (267).

² Cf. p. 283.

³ *Zeitschrift für Biologie*, v. 35, p. 335 (1897).

⁴ Cf. pp. 348-349.

⁵ Cf. Table, p. 348, Series C, Experiments Nos. 1 and 2.

necessity of drawing our final conclusions only from exact metabolism experiments. The soluble hemicelluloses show great diversity of behavior in the alimentary tract, although equally resistant to digestive enzymes *in vitro*; some disappear entirely, others reappear in the faeces in varying degree, up to 100 per cent. It is evident that the latter do not constitute a source of energy for the organism: how far the former actually do so, remains to be demonstrated.

IV. CONCLUSIONS.

1. The hemicelluloses of the ten species of marine algae included in these investigations are chiefly pentosans and galactans. The pentosans are largely insoluble in water, but a soluble form in considerable quantity has been isolated from *Rhodymenia palmata*. The galactans are soluble in hot water, and are characterized by their gelatinous nature. Small quantities of soluble pentosans have been found associated with them in every case.

2. In order of resistance to the action of bacteria, the hemicellulose groups studied stand as follows, — galactans, pentosans, levulans, mannans, the galactan of *Chondrus crispus* being entirely unaffected by common micro-organisms.

3. Aerobic and anaerobic cultures of soil and faecal bacteria, and cultures of *B. anthracis symptomatici* and *B. maligni oedematis*, caused inversion of salep mannan, with actual production of reducing sugar. The latter cultures also hydrolyzed the pentosan of *Rhodymenia palmata*, and the levulan, sinistrin. In a mixture of aerobes, salep appeared to be partially hydrolyzed, forming an insoluble transition product.

4. Digestion experiments *in vitro*, continued for 24 hours at body temperature under antiseptic conditions, have been almost entirely negative in result. The only exceptions are the hydrolysis of the pentosan of dulce, the galactan of limu kohu, and the levulan, sinistrin, by "Taka" diastase; and of sinistrin, and the galactans of limu kohu, limu akiaki, and slippery elm bark, by artificial gastric juice or 0.2 per cent hydrochloric acid, the action of the gastric juice being in all probability due to its acidity.

5. After parenteral injection, whether subcutaneous or intraperitoneal, the hemicelluloses are excreted through the kidneys, and can be recovered unaltered in the urine. The pentosan of dulce is completely eliminated in four to five days, and the carbohydrates of Irish moss, salep and sinistrin, in one to three days.

6. Feeding experiments show that those hemicelluloses most readily attacked by bacteria disappear most completely from the alimentary tract. The average coefficient of digestibility for man is, in the case of the pentosan of dulce and the mannan of salep, 99 per

cent notwithstanding their apparent resistance to amyolytic enzymes and the hydrolyzing influence of the gastric juice; their disappearance seems therefore directly attributable to bacterial activity, and the possibility of sugar formation by this agency having been demonstrated, it remains to be shown by means of respiration experiments to what extent materials so hydrolyzed can serve as true nutrients for the organism. Dogs can also utilize the dulse pentosan to a considerable degree, but their power to digest mannan is still an open question.

In striking contrast to the above hemicelluloses stand the galactans, with their high degree of resistance to bacterial decomposition; they show in man, an average digestibility of approximately 25 per cent, in dogs of 45 per cent. It is manifestly impossible to treat of the digestibility of hemicelluloses as a class, in view of such diversity in the groups. Not only must each type receive special consideration, but distinction must be drawn between soluble and insoluble forms, as is illustrated by the pentosans, the ratio of the digestibility coefficient of the former to the latter being approximately 100 to 50 in man, and 75 to 25 in dogs. We may, however, say in general, that they disappear from the alimentary tract of men and animals to an extent seemingly proportional to their susceptibility to attacks of micro-organisms, and give little justification for any high claims made for them as sources of energy in nutrition. They may, however, have a valuable function as adjuvants in the dietary, as therapeutic agents in constipation, or as sources of inorganic salts.

The author gratefully acknowledges the helpful suggestions and criticism freely given by Professor Lafayette Mendel throughout the progress of this work and the kindly interest and assistance of Professor Rettger in the bacteriological problems.

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New Spiders
from New England

BY

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NEW SPIDERS FROM NEW ENGLAND

BY J. H. EMERTON.

This paper describes 25 new species and 15 described species of spiders found in New England since the completion of the Supplement to the New England Spiders published in the Transactions of the Conn. Acad., Vol. 14, January, 1909. Two of these are European species apparently lately introduced: *Teutana grossa*, found in a museum basement in company with *T. triangulosa* and *Epeira diademata*, found at Newport, R. I., and evidently well established around the house of the Historical Society and for several blocks along the adjoining street. The two European species of *Zilla* are now abundant: *Z. x-notata* all over Cape Cod and the South shore of Massachusetts and Rhode Island and *Z. atrica* on Cape Ann and the adjoining country as far south as Fall River and Newport, but not far inland. *Zora spinimana*, a European spider, has been found several times in one locality only, but in a situation where there seems little probability of its being introduced. Four species first described from the Canadian Rocky Mountains have now been found in Northern New England. Of these *Linyphia humilis* is abundant among the dwarf firs and spruces at a height of 2000 to 4000 ft. on Greylock, Mass., Mt. Mansfield and Camel's Hump, Vt., Mt. Washington, N. H., and at the sea level in eastern Maine at Eastport. *Pedanostethus fuscus* described first from the Rocky Mountains under the name of *Steatoda* occurs at several places at about 2000 ft. elevation around Mt. Washington. The other two species are *Lycosa quinaria* and *L. beanii* found at Bangor and on Mt. Desert, Me. Of the native species, two were formerly included in others to which they are nearly related, *Ceratinella carinata* in *C. laetabilis* and *Pisaura brevipes* in *P. (Ocyale) undata*. The two species formerly included in *Phrurolithus alarius* have been separated and the larger one named *P. borealis*. The systematic relations of several species are doubtful, especially *Tmeticus armatus* Bks. which has pits in the sides of the head like *Lophocarenum* and male palpi like *Erigone* or *Gongylidium* with long setæ at the base of the tarsus as in *Tmeticus longisetosus* and *flaveolus*. *Histagonia nasutus* resembles *H. (exechophysis) palustris* Bks. but has the peculiar character of

the head exaggerated. Another species of special interest is *Microneta olivacea*. The male was described from Mt. Washington in 1882, the female was found by Britcher on Mt. Katahdin in 1901; but the relation between the two was not noticed until the discovery of both sexes in several localities in 1910. The female has a peculiar projection of the front of the head and thickened palpi resembling those of an undeveloped male and an epigynum of the *Microneta* type of unusual size corresponding to the large palpi of the male.

List of New Species.

<i>Ceratinella sphaerica.</i>	<i>Bathyphantes intricata.</i>
" <i>carinata.</i>	" <i>theridiformis.</i>
<i>Araeoncus bispinosus.</i>	<i>Diplostyla brevis.</i>
<i>Dicymbium pectinatum.</i>	<i>Dictyna terrestris.</i>
<i>Histagonia nasutus.</i>	<i>Argenna obesa.</i>
<i>Lophocarenum excavatum.</i>	<i>Pisaura brevipes.</i>
" <i>arenarium.</i>	<i>Pardosa muscicola.</i>
" <i>domiciliorum.</i>	<i>Liocranum calcaratum.</i>
" <i>flagellatum.</i>	<i>Micaria longispina.</i>
<i>Tmeticus aestivalis.</i>	<i>Phrurolithus borealis.</i>
" <i>tarsalis.</i>	<i>Prosthesima transversa.</i>
" <i>entomologicus.</i>	<i>Sittacus striatus.</i>
" <i>tenuipalpis.</i>	

Described species lately found in New England.

<i>Teutana grossa</i> K.	<i>Lathys foxii</i> Marx.
<i>Pedanostethus fusca</i> Em.	<i>Lycosa quinaria</i> Em.
<i>Lophocarenum bilobatum</i> Bks.	<i>Lycosa beanii</i> Em.
" <i>exiguum</i> Bks.	<i>Phrurolithus minutus</i> Bks.
<i>Tmeticus armatus</i> Bks.	" <i>formica</i> Bks.
<i>Grammonota tricittata</i> Bks.	<i>Zora spinimana</i> Sud.
<i>Linyphia humilis</i> Em.	<i>Dendryphantes castaneus</i> Hentz.
<i>Epeira diademata</i> Cl.	

Theridion globosum, Hentz.

The male of this species is 2 mm. long with the first leg 5 mm. long. The head extends forward a little more than in the female and the front middle eyes are as far from the upper middle pair as they are from each other. The abdomen is round and not as much elevated as in the female; it has a black spot on the hinder half, but the light area around it is not as distinct as in the female. There is a black spot in the middle of the under side of the abdomen. Pl. I, fig. 1.

The male palpus has the tarsus prolonged into a slightly curved horn, and opposite this on the outer side of the palpus the bulb extends into a sharp point curved like the horn, but half as large. Figs. 1a, 1b.

Fitzwilliam, N. H., with female, July 21, 1907. Blue Hills, Milton, Mass., Miss Bryant, June 25, 1904. Cold Spring Harbor, Long Island, N. Y., July 4, 1907.

Teutana grossa, Koch.

Female 8 mm. long, cephalothorax 3 mm. The cephalothorax is shaped as in *triangulosa*, but the sternum is heartshaped and does not extend backward between the fourth coxæ. The cephalothorax and legs are dull yellow without any markings. The abdomen is purplish brown with lighter markings forming a half circle near the anterior end and a middle row of triangles. Pl. I, fig. 2. On the under side the abdomen is of the same color with fine oblique lighter lines at the sides. The epigynum has a dark semicircle across it in front, much as in *triangulosa*. Fig. 2a.

One female in company with *triangulosa* in cellar of the building of the Boston Soc. Nat. Hist. A European species probably introduced.

Pedanostethus fuscus.

Steatoda fusca, Em. Canadian Spiders, Trans. Conn. Acad., 1894.

This species has now been found in the White Mountains in the Carter Notch, Crawford Notch and the Great Gulf of Mt. Washington. It resembles *P. pumilus* but is one-half larger. In size and color it is like *Tmeticus brunneus* with which it lives. The epigynum is without

any anterior hard appendage. See Trans. Conn. Acad. 1894. The palpus has the tarsus shaped as in *pumilus*. At the base of the palpal organ on the inner side the process is longer and sharper at both ends than in *pumilus*. Figures are given of this process in the four species of *Pedanostethus*. Pl. I, figs. 3, 3a, 3b, 3c.

***Ceratinella sphaerica*, new.**

Males 1 mm. long. Cephalothorax as wide as long and two-thirds as high in front as it is wide. Abdomen round, as wide as long and nearly as high, extending forward over the cephalothorax half its length. Hard covering of the abdomen extending underneath as far as the pedicel and the spinnerets, and covered as in other species with minute pits and hairs. Pl. I, figs. 4, 4a. The color is dull, the cephalothorax and abdomen nearly black, and the legs yellowish gray. The sternum is wider than it is long and between the fourth coxæ as wide as it is in front. The male palpi are as long as the cephalothorax. The patella and tibia are of the same length and the tibia but little widened at the front. The outer process is slightly curved outward and downward. Fig. 4c. The palpal organ is of the usual structure in the genus, with all the parts of moderate size and length. Fig. 4b.

Two males under leaves in moist woods, Tyngsboro, Mass.

***Ceratinella carinata*, new.**

Like *C. laetabilis* except in the palpi of the male. The palpi have the tibia narrower than in *laetabilis*, not more than twice as wide as long and the wide black tooth is a fourth smaller. The tarsus has on the outer edge three dark ridges that from some directions look like spines and between the two outer ridges are a few minute hairs. The whole tarsus is slightly smaller than in *laetabilis*. All the males found in a bog at Springfield, Mass., and near the Wayside Inn in Sudbury are of this species. In Concord, Mass., this and *laetabilis* were found together. The tarsus of the male palpus of *C. laeta* has ridges on the outer edge similar to those in *carinata*. Pl. I, figs. 5, 5a, 5b, 5c, show the tarsus and tibia of males of this species compared with *laetabilis*, *laeta* and *brunnea*.

***Grammonota trivittata*, Bks. Journ. N. Y. Ent. Soc., 1895.**

2 mm. to 2.5 mm. long, more slender than *G. ornata* and with longer legs. The palpi of the male are as long as the cephalothorax, while in *ornata* they are shorter. The color is generally lighter than in *ornata*. the head is lighter than the thorax, while in

ornata the head is darkest. Pl. I, figs. 6, 6a. The light spots of the abdomen are united more closely than in *ornata*, and form two serrated longitudinal stripes. The male palpus has the patella and tibia both longer than they are wide, and the whole palpus longer than in *ornata*. The palpal organ resembles that of *ornata*, but is slightly smaller. Figs. 6b, 6c.

Salt marshes from Gloucester, Mass. to Long Island N. Y.

Grammonota gigas, Em. Trans. Conn. Acad., 1909.

Erigonoplus gigas, Bks. Canadian Entomologist, 1896.

Plum Island, Mass., June 17, 1910, under straw on growing grass at edge of salt marsh. The markings of the abdomen are more uniform than in *ornata*, the front light spots not much larger than the others. The female has the head slightly raised behind the eyes. The epigynum has the middle depression square instead of narrowed in front as it is in *ornata*.

Araeoncus bispinosus, new.

Male 1.5 mm. long. Cephalothorax as wide as long and a little narrowed in front. The top of the head is elevated abruptly with shallow grooves, but without any holes at the sides. Pl. I, fig. 7. The sternum is convex and as wide as long. Fig. 7c. The upper middle eyes are farther from the front middle eyes than from each other and are farther back than the posterior lateral eyes. The male palpi have the patella more than twice as long as wide. The tibia is short and widened on the inner side where it has a long, fine spine, slightly curved and extending over the back of the tarsus. Near the base of the spine is a shorter one sharp-pointed and curved inward. Fig. 7a.

Two males only, Springfield, Mass., Sept. 20, 1909.

Dicymbium pectinatum, new.

Male 1.5 mm. long, dull gray, with lighter yellowish legs. The cephalothorax is high in front with the head highest just behind the eyes, Pl. I, fig. 8, but without any holes at the side of the head. The upper middle eyes are very little larger than the front middle eyes. The first legs are a little thicker than the others, and the first metatarsus has on the upper side a single row of seven large hairs. Figs. 8, 8a. The male palpi are as long as the cephalothorax. The patella is long, nearly as long as the femur. The tibia is short and wide and hollow on the under side, in the middle of which the tarsus is

attached. Fig. 8d. The end of the tibia is obliquely truncated and the outer corner has a small recurved point. Fig. 8c. The tarsus is round and the palpal organ small and simple. The palpus resembles that of *Dicymbium gracilipes* of Europe.

One male only under leaves at Three Mile Island, Lake Winnepesaukee, Oct. 10, 1909.

Histagonia nasutus, new.

Male 2 mm. long. The front of the head extends forward beyond the mandibles and upward as high as the front eyes, covered on the highest part with short hairs directed upward and backward. The head is elevated and the eyes all turned upward. Pl. I, figs. 9, 9a. Seen from above the cephalothorax appears pointed in front as in *H. palustris*. The abdomen is oval and the whole body dull gray without markings. The male palpi resemble those of *H. palustris* but the tibia is more simple and the parts shorter and less pointed without the distinct wedge-shape when seen from above in *palustris*. The palpal organ is much as in *palustris* with the tube shorter and the support longer and more pointed.

One male only with *palustris* in dust and leaves washed up on the shore at Three Mile Island, Lake Winnepesaukee, N. H.

Lophocarenum bilobatum.

Dicyphus bilobatus, Banks. Canadian Entomologist, 1896.

In size and color this resembles *L. decemoculatum*. The cephalothorax and legs are bright orange and the abdomen bluish black. The cephalothorax is nearly as wide as long, rounded in front and without the projection over the mandibles which is so distinct in *decemoculatum*. The hump is divided into two distinct lobes, each oval, and about twice as long as wide. Pl. II, fig. 1. The holes in the head are close behind and a little higher than the upper lateral eyes, fig. 1a, appearing from in front like an additional pair of eyes as in *decemoculatum*. Behind the two lobes and around their outer sides the cephalothorax is slightly elevated. The male palpi are more slender and the palpal organs smaller than in *decemoculatum*. The tibia has on the upper and inner side a slender, slightly curved hook, extending along the edge of the tarsus more than half its length. Fig. 1. The palpal organ is simple, the tube and a soft conductor arranged as in *decemoculatum* and *florens*, but smaller and more slender. Fig. 1b.

So. Framingham, Mass., from low plants on the edge of a flooded meadow, May 15, 1910.

Lophocarenum exiguum, Bks. Proc. Phil. Acad., 1892.

Length of male 1.5 mm. Legs pale, but the rest of the body dark; the cephalothorax yellow brown and the abdomen gray. The sternum is dark brown but the coxæ as well as the rest of the legs are pale. The head of the male is high and has a narrow vertical hump with the upper middle eyes on top of it. Pl. II, fig. 2, 2a. There are grooves in the head extending forward over the upper lateral eyes so that the edge can be seen from in front. Fig. 2a, 2c. The female has no trace of the hump. The male palpus has the patella short and the tibia flattened and divided into two branches, the upper branch flat and turned nearly vertical, and the lower branch curved in a flat hook over the back of the tarsus. Figs. 2a, 2b. The upper branch of the tibia is irregularly toothed with a large tooth at the upper and one at the lower corner. Fig. 2b.

Woodbridge, near New Haven, Conn. Miss E. B. Bryant in Mus. Comp. Zool. Found by Banks at Ithaca, N. Y.

Lophocarenum excavatum, new.

Male and female 2 mm. long. Abdomen punctate all over with short scattered hairs in the depressions. In the male there is a thickened shield covering the dorsal half of the abdomen as in *Ceratinella*. Pl. II, fig. 3. The abdomen and cephalothorax are chestnut brown, except the top of the hump on the head of the male, which is pale like the legs and palpi. In the male the head is divided into two parts by a notch in front and the upper half forms a rounded hump carrying in front the upper middle eyes. Figs. 3, 3a. On each side of this hump is a deep oval depression. In the female the middle eyes are far apart but there is no trace of the hump. The male palpus has the patella long and the tibia short, with a long process on the upper side ending in a small hook. Figs. 3, 3b. The tarsal hook and the parts of the palpal organ are all small. Fig. 3b. The epigynum is flat and simple in form. Fig. 3c.

Ipswich, Aug. 18, 1908, under straw on the edge of the salt marsh.

Lophocarenum arenarium, new.

Head slightly raised as in *simplex* and *erigonoides*. The pits are only a little farther back than the upper middle eyes, and are small and not easily seen. The lower middle eyes are higher than the lower lateral pair. The face below the eyes extends forward and

is covered with short, stiff, black hairs directed upward. Pl. II, Figs. 4, 4a. The first and second legs have similar short, stiff hairs on the under side. On the femur the hairs are clustered at the base and are smaller and in two rows toward the tip. On the tibia they are longer and in eight or ten pairs, and on the metatarsus and tarsus they are finer and more like ordinary hairs. The first and second legs are slightly thicker than the others. The cephalothorax is as wide as it is long. The sternum is as wide as long, and extends between the fourth legs where it is as wide as one of the coxæ. The male palpi are short with the patella about twice as long as wide and widened at the end. The tibia is not widened laterally but extends upward over the tarsus, ending in a slightly curved tip on which is a small incurved point. Figs. 4, 4b. The tarsal hook is simple in form, and its base follows the curve of the tibia. The tube of the palpal organ is long and slender, and makes one turn around the end of the bulb, supported at the end by a thin appendage half its own length. Fig. 4b.

The female is the same size and color as the male and has the head a little elevated, but no unusual arrangement of hairs on the head or front legs. The epigynum is short and wide, showing through the skin round receptacles more than twice their diameter apart. Fig. 4c.

One male, Ipswich, Mass., May 12, 1908 under straw at Lakeman's Beach. Males and females on salt marsh at Oak Island, Lynn, Mass.

Lophocarenum domiciliorum, new.

From cellar of Boston Society of Natural History, November, 1910. The head is only slightly elevated behind the eyes. The upper row of eyes, seen from above, is nearly straight. At the sides of the head beginning just behind the upper lateral eyes are deep grooves extending backward half the length of the head, with shallow and pointed pits near the anterior end. Pl. II, figs. 5, 5a.

The male palpus has the patella as long as wide and the tibia a little longer, widened at the anterior end, with a long, sharp point on the inner side. The tarsus is oval and the palpal organ small and simple. Figs. 5b, 5c.

During the autumn flights great numbers of small spiders are blown into Boston and alight on the fences of the common and the streets west of it. This spider probably came into the city in this way.

Lophocarenum flagellatum, new.

Male a little over 1 mm. long. The cephalothorax high in front and highest behind the eyes. At the sides of the hump are grooves with a round pit at the anterior end. The grooves are unusually far behind the eyes and when seen from above resemble those of *L. minutum*; the head, however, is much higher than in that species. Pl. II, figs. 6, 6b. The male palpi also resemble those of *minutum*. Their patella and tibia are both short but the tibia shortest. The tibia is widened at the end and has a long, slender process extending over the outer side of the tarsus nearly its whole length, and slightly hooked at the tip. Fig. 6.

One male from Seal Harbor, Mt. Desert, Me., July 1, 1909.

Lophocarenum florens and **decemoculatum**.

Several females found with males in the early summer of 1909 show the differences between these two species which in general appearance closely resemble each other. The epigynum of *florens* is already well figured in N.E. Therididæ, Trans. Conn. Acad., 1882. That of *decemoculatum* is shown in a new figure, Pl. II, fig. 7b. The eyes of *florens* are farther apart than those of *decemoculatum* and the upper middle eyes are higher and farther from the front middle pair than they are from each other. In *decemoculatum* the middle eyes nearly form a square, the upper pair being only a little farther apart than the front pair. Figs. 7, 7a.

Lophocarenum (Tmeticus) armatum Bks. Proc. Ent. Soc. of Washington, Feb. 1, 1906.

Male 4 mm. long. Cephalothorax and legs orange yellow, abdomen bluish gray. The head is slightly elevated and there is a shallow groove and a small round hole close behind the lateral eyes. Pl. II, Figs. 8, 8a. The upper middle eyes are farther from the front eyes than from each other. The mandibles are large and with several large spines. In front and showing from above is a large pointed tooth pointing downward. On the inner side of the mandible, near the middle, is a large tooth and nearer the base two others, and there are several small teeth and processes around these larger ones. Figs. 8, 8a, 8b. The maxillæ are wide and project sidewise beyond the sternum. Their front edge has a double tooth at the outer corner. The sternum is widest in front, where it is nearly as wide as long. At the hinder end it has a narrow projection between the fourth coxæ. Fig. 8b. The palpi are long and resemble those of *Erigone* having a similar tooth directed downward on the patella.

Fig. 8f. The tibia is widened at the end as in *Erigone* and *Gongylidium*. At the base of the tarsus are three stiff bristles like those of *Tmeticus longisetosus*. Fig. 8e.

The female is 3 mm. long, colored as in the male, but paler. The eyes have a similar arrangement, but are not elevated above the cephalothorax. The mandibles are large but without unusual processes and have five teeth on the front of the claw groove. The maxillæ are wide and project a little beyond the sternum. The sternum is wide in front, widest between the first and second legs, and projects backward between the fourth coxæ. The epigynum is shown in Fig. 8d.

White Mountains, N. H., near the Crawford Notch, sifted from leaves, Sept. 25, 1908. Banks described it from Manitoba.

***Tmeticus aestivalis*, new.**

1.5 mm. long. Cephalothorax nearly as wide as long and the abdomen narrower and oval. The sternum is as wide in front as it is long, and varies in shape. In some males it is almost triangular, with the sides straight and the widest part just behind the first legs, but usually the sides are slightly curved to the fourth coxæ, where the sternum is very narrow and extends between them. The male palpus has the tibia nearly as wide as long and divided at the front end, the outer branch curving outward. The tarsal hook is large and grooved on the outer side with two teeth at the end, the outer one largest and curved toward the other. At the end of the palpal organ is a black forked appendage bent toward the bulb and pointed forward and outward. Pl. III, figs. 1, 1a, 1b.

The female is as large as the male, with the cephalothorax not quite as wide. The epigynum appears without magnifying as two parallel dark stripes, at the anterior end of which the small round receptacles show through the skin. Fig. 1c.

Mt. Toby and Holden, Mass., in June under leaves.

***Tmeticus tarsalis*, new.**

2 mm. long. Cephalothorax nearly as wide as long, with the whole anterior half elevated. Pl. III, fig. 2. The eyes are slightly raised above the rest of the head and the front of the cephalothorax from the eyes to the mandibles is nearly vertical. The male palpi are as long as the cephalothorax, with the tarsus and palpal organ large and rounded, and a very long tube thick at the base and coiled entirely around the tarsus. Fig. 2a. The tibia is short and small, showing above two short teeth. The tarsal hook

is bent at a sharp angle, as in *T. debilis*. The outer edge of the tarsus which is without hairs and separated from the rest by a sharp ridge has a wide rounded lobe in front of the tarsal hook. Fig. 2b.

Fall River, Mass., Mt. Mansfield, Vt., Crawford Notch, N. H.

***Tmeticus entomologicus*, new.**

Only 1 mm. long and dull gray. The cephalothorax is one-fourth longer than wide and the head low, and a little narrowed. The front row of eyes is one-fourth shorter than the upper row, the front eyes are close together and the middle eyes only half the diameter of the lateral. The male palpi have the tibia elongated on the upper side and truncate at the end. The tarsal hook is curved in a half circle and simple in form. Pl. III, fig. 3. The tarsus is short and round and the palpal organ large with a short tube and two large processes.

Ipswich, L. R. Reynolds, and Tyngsboro, Mass., F. Blanchard, under leaves in May and June.

***Tmeticus tenuipalpis*, new.**

Males and females 3 mm. long. Abdomen high and round and marked as in *T. probatus* with light spots in pairs. The legs and palpi are long and slender. The general color is dull gray without markings except the spots on the abdomen. The mandibles are very large in both sexes. In the male the mandible has on the front and outer side a row of five stout teeth, smallest toward the head. Pl. III, figs. 4, 4b. On the under and inner side are two rows of long teeth, four in the outer and five in the inner row, between which the claw is folded. Fig. 4a. The maxillæ are long and wide, with blunt teeth at the sides, extending beyond the sternum. The trochanter has also a short tooth on the under side. The male palpi are unusually slender and nearly twice as long as the cephalothorax. The tibia is slightly widened at the end with short teeth around it. The tarsus is more than twice as long as wide and the palpal organ occupies only the basal half. The tarsal hook is short and without any prominent points or hooks. Figs. 4c, 4d.

The female has the same rows of spines on the mandibles as the male, but all much smaller. The epigynum is very simple. Fig. 4e.

Ipswich, under straw on the edge of the salt marsh, August 1908 and 1909.

Microneta olivacea, Emerton. N. E. Therididae, Trans. Conn. Acad. 1882.

The male is 2 mm. long, the cephalothorax 1 mm. The cephalothorax is as wide as long and wider than the abdomen. In front it extends forward slightly beyond the eyes and beyond the mandibles. The eye area is a little elevated. Pl. III, fig. 5, 5b. The mandibles are narrowed at the ends and have one very small tooth near the inner angle. The male palpi are of the microneta type but unusually large. The tarsus is angular and has a small spur at the base. Figs. 5, 5a. The tarsal hook is wide and flat with a tooth at the end and a wider one at the angle.

The female is as long as the male but has the cephalothorax a fourth longer than wide. Fig. 5g. The color is lighter than in the male and yellowish brown rather than gray. The cephalothorax extends forward beyond the eyes farther than in the male and projects distinctly beyond the mandibles. Fig. 5c. The mandibles are slightly curved forward at the ends as they are in the male, but are not much narrowed, and the single tooth is large. Fig. 5f. The palpi have the tarsus thickened in the middle so that it appears like that of an immature male. Figs. 5d, 5h. The epigynum is folded and resembles that of other *Microneta* and *Bathyphantes*. Figs. 5i, 5k.

The female was found by the late H. C. Britcher on Mt. Katahdin, Me., in 1901, and has since been found with males on Greylock and Mt. Mansfield.

Three females found with two males at Norcross, Me. June 30, 1910, resemble those from other places except that the palpi are not swelled at the end. Fig. 5e. The males agree with those from other places.

Bathyphantes theridiformis, new.

Cephalothorax 1 mm. long. Whole body 2 mm. long in male and 3 mm. in female. Color pale with gray markings resembling *Theridion sexpunctatum*. The cephalothorax has a wide middle dark stripe as wide in front as the eyes and tapering slightly backward. There is a dark line along the sides of the cephalothorax nearly to the eyes. The legs are slightly gray on the ends and middle of each joint. The abdomen has on the back a dark mark over the dorsal vessel and a series of pairs of irregular dark spots more or less united with spots along the sides and with each other.

On the under side the coxæ and mouth parts are pale and the sternum gray. The abdomen is gray, lighter in the middle, and

darker along the sides, the markings varying in individuals and sometimes broken into irregular spots.

The male palpi have the tarsus with a small process at the base on the upper side. The tarsal hook is curved outward at the end where it has two points, the distal one much the longer. Fig. 6a. The mandibles of the male are turned apart from the middle, where two of the teeth along their edge are much larger than the others. Fig. 6b.

The epigynum is short and wide, the outer fold in two lateral lobes, with a small middle one. Fig. 6c.

Jackson, N. H., June 1, 1910.

Bathyphantes intricata, new.

3 mm. long and pale, without any markings. Cephalothorax and legs yellowish and the abdomen gray. The legs long and slender, the front pair 8 mm. long. The male palpi have the tibia and patella short and of the usual form, without processes, but the tarsus and its appendages are extremely complicated, as best shown in the figures. The tarsus has a sharp angle on the upper side and a process at the base and both these are elongated into sharp, curved teeth. Pl. III, figs. 7, 7d. The tarsal hook is hard to describe. It has all the curves and angles found in this genus and all exaggerated into teeth and ridges.

Three Mile Island, Oct. 20, 1909.

Diplostyla brevis.

Like *nigrina* in size and color, varying in length from 2 mm. to 3.5 mm. and in color from pale to dark gray, almost black. As in *nigrina* the markings of the back of the abdomen, especially near the front end, may be small gray spots in pairs on a pale ground or they may be pale spots in a general dark gray. On the under side this species is generally lighter than *nigrina*, having two pale stripes sometimes extending the whole length or sometimes only partway backward from the epigynum with the space between the stripes, in some individuals, nearly as pale as the stripes themselves.

The epigynum has the two median finger-like appendages not more than half as long as in *nigrina*. Pl. IV, fig. 1b. The male palpi have the tarsus a little shorter and less angular than in *nigrina*. Figs. 1, 1a. The tarsal hook has a blunt point not widened at the tip as in *nigrina*. Fig. 1. The palpal organ has the middle process on the under side not straight as it is in *nigrina*, but curved

around the base of the tube, and usually pointed at the tip with a tooth on the outer side; but this varies in different individuals. Fig. 1a.

Under leaves at all seasons. Tyngsboro, Cambridge, Mt. Mansfield, White Mountains. Flying from fences, Readville, Mass., in November.

Linyphia humilis, Em. Canadian Spiders, Trans. Conn. Acad. Vol. IX, 1894.

This species first described from the Rocky Mountains of Canada has now been found on the upper part of the Green Mountains, from Mt. Mansfield, Vermont, to Greylock, Mass., on Mt. Willard in the White Mountains, and at the sea level at Eastport and Machias, Me. It lives in the low firs and spruces that cover the tops of Greylock and Mansfield, and has not been found there below 2000 feet; and from 2000 to 4000 feet on Mt. Washington, most abundant in the dwarf trees along the road near the Half-way House, and becoming scarcer downward as far as the path to Hermit Lake. Found in the Great Gulf near the Appalachian Club camps. In Maine it lives also where the forest consists largely of stunted spruces in company with *Theridion zelotypum*. Both males and females are found in the Green Mountains in great abundance in the middle of June, and the young in September. The shape of the abdomen of the female is slightly pointed behind and high in the middle. Pl. IV, fig. 2c. The dorsal marking is divided by two notches at the sides into three parts, the middle part much smaller than the other two. Fig. 2b. The colors resemble *communis*, for which it may be sometimes mistaken. In the male the colors are much brighter, the cephalothorax and legs light orange and the abdomen brown. The head of the male is as high as it is wide and black between the eyes. The male palpi resemble those of *L. marginata* and have the tarsal hook showing plainly from above, curved in a half circle with the end slightly widened. Fig. 2a. The epigynum is shown in fig. 2d. See also figures in Trans. Conn. Acad. Vol. IX.

Epeira diademata, Cl.

Newport, R. I. on window frames, fences and vines around the building of the Historical Society and fences of neighboring gardens on Touro Street, Sept. 20, 1910. One adult ♂ under fence cap. Large females with nest above the web. A common European species reported from Vancouver, Wisconsin and Newfoundland, but now found for the first time in New England.

Zilla x-notata, Z. atrica.

Z. x-notata described in Trans. Conn. Acad., Vol. VI, 1884 from Woods Hole, Mass. is abundant at Provincetown, on wharves, barns and houses near the shore; also at Wellfleet and Harwich and at Newport, R. I., on the street fences; New Bedford on wharves and fish houses; and Fall River on boat houses, but in small numbers. None were found at Dighton and Taunton. On the same street at Newport where *Z. x-notata* is found on the fences *Z. atrica* occurs in hedges. It is also common at Fall River on hedges, fences and garden shrubs. At Taunton this species was absent, as well as *x-notata*.

Dictyna terrestris, new.

2 mm. long and resembling closely *D. volupis*. The front middle eyes are farther forward than in *volupis*, so that the middle eye area is longer than wide. Pl. IV, figs. 3c, 3d. The male palpus has the tibia short, not longer than wide, except on the outer side. The tarsus and palpal organ are very large and both curved downward more than in *volupis*. Fig. 3b. The mandibles of the male are not turned forward at the ends as much as in *volupis*.

Three Mile Island, N. H., June 1. Plum Island, Mass., June 17.

Argenna obesa, new.

Female 2.5 to 3 mm. long. Cephalothorax 1 mm. The whole body pale, cephalothorax a little darker than the abdomen. The hinder half of the abdomen indistinctly marked with angular spots. Pl. IV, fig. 4a. The abdomen is oval and longer than the cephalothorax. The head is wide and but little elevated. The front middle eyes are smallest, but only a little smaller than the upper middle pair, and the front eyes form a nearly straight row at equal distances from each other. The sternum is nearly as wide as long, and with a blunt point behind that extends backward between the fourth coxæ. The cribellum is small and undivided. Fig. 4. The fourth metatarsus is slightly curved and the calamistrum extends about half its length.

The male differs from the female in the smaller abdomen and longer and larger front legs. The male palpi have both the patella and tibia short and wide. The tarsus is nearly as wide as long and pointed at the end. The tibia has a wide process that extends forward along the outer side of the tarsus and against this lies a wide pointed appendage of the palpal organ supporting the end of the tube, somewhat as in *Dictyna*. Figs. 4c, 4d, 4e.

Abundant under straw on the edge of salt marshes at Ipswich and Plum Island. Adult males in June and July, Cold Spring Harbor, Long Island, N. Y., Miss Bryant.

Lathys foxii = Prodalina foxii, Marx. Ent. Soc. Washington, 1891.

2 mm. long. Pale, with the cephalothorax a little darker than the abdomen. Abdomen marked with a middle row of brown angular marks that in some individuals join a row of spots along the sides. Pl. IV, fig. 5. In the male the dark marks are wider so that there appear to be light marks on a darker ground. The front row of eyes is shorter than the upper row and the front middle eyes much smaller than the others. Pl. IV, fig. 5e. The sternum is nearly as wide as long, with a blunt point behind which extends between the fourth coxae. The cribellum is small and undivided. Fig. 5a.

The male palpi have the patella and tibia both very short. The patella is widened at the end so that seen from above it is twice as wide as at the base. The tibia is also widened at the end and has a groove above in which rests the end of the tube of the palpal organ, which extends along the outer side of the tarsus and turns inward and upward between tarsus and tibia. Fig. 5d.

Under leaves at all times in summer and autumn. Males from Hollis, Me., June 12. Females from Old Orchard Beach, Me., Holden, Carlisle, Huntington, Williamstown, Mass.; Kent, Conn.

Pisaura brevipes, new.

A smaller and dark form of *Pisaura* formerly placed with *P. undata*. It is one-sixth smaller than *undata* and dark brown even when small and freshly molted, and the middle stripe has nearly straight sides, both on cephalothorax and abdomen, with a bright white line along its edges. The sides of cephalothorax and abdomen are dark brown. The legs are brown without rings. The first leg is shorter than the fourth and without the femur is shorter than the body, while in *P. undata* the first leg without the femur and patella is as long as the body. Pl. IV, figs. 6, 6b. The epigynum is slightly shorter and rounder than in *undata*. Figs. 6a, 6c.

Females from Mt. Tom, July, 1873, So. Framingham, May, 1910.

Lycosa quinararia, Em. Canadian Spiders, Trans. Conn. Acad., Vol. IX, 1894.

The male is 8 mm. long, the cephalothorax 5 mm. long, the fourth leg 14 mm. and the first leg 13 mm. The cephalothorax shows no markings in alcohol, and the legs have no spots or rings, but are irregularly striped lengthwise as in *Pardosa glacialis*. The male

palpi are long and the tibia as long as the tarsus. The abdomen is gray with a white middle stripe more than half its length, continuing to the end in a row of spots. At the sides are similar spots in irregular rows. Pl. V, figs. 1, 1a.

Male in sphagnum bog, Bangor, Me., June 29, 1910. Female from Laggan in the Rocky Mountains in Canada. See Trans. Conn. Acad., Vol. IX.

Lycosa beanii, Em. Canadian Spiders, Trans. Conn. Acad., Vol. IX, 1894.

This species has the general appearance of *frondicola*. The middle stripe of the cephalothorax is straight at the sides and narrowed from the eyes backward. The femora are marked with indistinct rings and there are traces of rings on the other joints. The under side is somewhat lighter than the back and has no black spots or stripes. The epigynum is well shown in the figure in the paper on Canadian spiders.

Seal Harbor, Mt. Desert, Me., July 1, 1909.

Pardosa muscicola, new.

The male of this species has been confounded with *uncata* and the female with *glacialis*. The markings are much like *glacialis*, with the middle stripe of the cephalothorax more distinctly divided into three at the anterior end. The lance-shaped spot at the front end of the abdomen is equally distinct in both. The femora of *muscicola*, however, are marked with four distinct but somewhat broken rings resembling the femora of *tachypoda* and *uncata* rather than *glacialis*. Pl. V, fig. 2. The epigynum is wide as in *glacialis* but the anterior pit is single and the middle lobe straight with parallel sides in the posterior half. Fig. 2c. The male is rather lighter colored than that of *glacialis* and the tarsus and tibia of the male palpus are not black as in that species but colored as in *uncata*. The basal process of the palpal organ is shaped as in *uncata* but the long branch is longer and extends entirely across the tarsus, ending in a slightly curved blunt point. Fig. 2a, 2b.

This species lives with *glacialis*, *uncata* and *tachypoda* on the moss of the upper part of the Green Mountains and White Mountains and in Labrador and Newfoundland.

Pirata montanus, Emerton. Trans. Conn. Acad., Vol. VI, 1885.

The female only is described in N. E. Lycosidæ, Trans. Conn. Acad., 1885. The male resembles the female in size and markings

but has greater contrasts in colors, and the legs marked with black. It is 5 mm. long and the cephalothorax 3 mm. The eyes as in the female extend over nearly the whole width of the head and the two upper pairs are nearly as large and conspicuous as in *Pardosa*. The femora of legs 1 and 2 are black and the other femora have black spots near the end. The cephalothorax is black with the usual light middle stripe divided in front into three, and extending forward between the eyes. Fig. V, fig. 3. The abdomen is gray, turning a little reddish in alcohol. It has a distinct light and dark pattern consisting of the usual pointed middle mark in front, and a series of bright white spots of hairs and narrow white marks along the sides toward the front, varying in different individuals. The front of the head and mandibles are black and the under side of the body gray, with a narrow light line on the sternum as in the female. The male palpi are very simple, much as in *P. minuta*. Fig. 3a. The basal part of the palpal organ has a flat border that extends forward, nearly covering the short tube and a thin appendage of variable shape near the outer end of the tarsus.

Males and females from Mt. Toby in the central part of Massachusetts, June 12, 1902. Mt. Everett, Mass. Ithica, N. Y.

***Liocranum calcaratum*, new.**

Both sexes 2.5 mm. long. Cephalothorax slightly longer in the male than in the female. The cephalothorax and legs are pale yellow brown, the cephalothorax sometimes brighter and redder than the legs. The abdomen is short, oval, and pale, with gray markings,—a middle stripe extending from the front to the middle and four or five transverse stripes, the second and sometimes the first connected with the middle stripe. Pl. V, figs. 4, 4c. Legs 1 and 2 have five pairs of long spines under the tibia and three pairs under the metatarsus in both sexes. Fig. 4b. The head is narrowed toward the front. The eyes are in two rows, nearly parallel, the front row shortest with the middle eyes much smaller than the lateral. The upper row of eyes is slightly curved downward at the ends and the eyes are of the same size and equal distances apart.

The male palpus has the tibia half longer than wide with a short process curved forward on the middle of the outer side. The tarsus is nearly as wide as long and pointed at the end. The tube of the palpal organ is short and has opposite to it a supporting process about the same size and shape. Figs. 4e, 4f.

Females, Crawford Notch, Sept. 20, Great Gulf of Mt. Washington, Aug. 1. Males, Jackson, N. H. June 1, Katahdin, Me. July 4.

Zora spinimana, Snd.

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5 mm. long, cephalothorax 2 mm. long and 1.5 mm. wide. The cephalothorax is narrowed in front where it is less than 1 mm. wide. The eyes are all nearly of the same size, the front row slightly curved backward, and the upper row strongly curved as in *Dolomedes*. The color is pale with distinct dark brown stripes and spots. The cephalothorax has two dark stripes extending straight backward from the lateral eyes and two less definite stripes along the edges. The abdomen has two stripes made up of irregular spots a little farther apart than the stripes of the cephalothorax, and between these two rows of smaller spots converging behind. Pl. V, fig. 5. On the under side the whole body is pale with scattered dark spots. The under pair of spinnerets have a brown stripe on the outer side. The legs are spotted and have a dark ring at the end of the metatarsus, which in the first legs covers nearly the whole joint. The tibia of the first leg is thickened in the middle and has underneath two rows of spines 7 on the outer and 8 on the inner side. Fig. 5b. The metatarsus of the first leg has underneath three pairs of long spines. The second leg has the same thickening in a less degree and similar, but smaller spines. The epigynum has two indistinct openings in front between and behind which a pair of curved tubes and large round receptacles show through the skin. Fig. 5a.

Tyngsboro, Mass. under leaves, mature female, Oct. 16 and immature female in January. A common species in Europe.

Micaria longispina, new.

Male 2.5 mm. long, resembling in form and color *M. gentilis*, but smaller than the usual size of that species. The male palpus has the tibia and patella both short, together as long as the tarsus. The tibia has a long process on the outer side, turned obliquely upward along the edge of the tarsus. Pl. V, figs. 6, 6a, 6b.

Ellisville, Plymouth, Mass., May 10.

Phrurolithus formica, Banks. Journal N. Y. Ent. Soc., 1895.

Found only in nests of the ant *Cremastogaster lineolata*. Males and females are 3 mm. long, in life dark gray, turning to brown in alcohol. Pl. VI, fig. 1. The legs are a little paler and the abdomen a little darker than the general color. The abdomen has a hard shining shield covering the whole upper surface. The front half of the under side of the abdomen is pale, the spot varying in size in different individuals. The epigynum shows externally a large

dark brown area, widest behind and nearly square, with rounded corners, behind which the receptacles show indistinctly through the skin. Fig. 1b. Smaller and apparently younger females have the epigynum more distinct without the opaque brown area. Fig. 1c. The male palpi are large and of characteristic form. Figs. 1d, 1e. The femur has a knob-shaped process on the middle of the under side. The process on the outer side of the tibia is short and wide with a long pointed tooth on the upper corner. Figs. 1d, 1e. On the inner side of the tibia is a large blunt tooth. The palpal organ has a large thick bulb with a long slender tube turned inward toward the tip of the tarsus.

Forest Hills, Boston, Mass., W. M. Wheeler, Tyngsboro, Mass., F. Blanchard. Found by Banks on Long Island, N. Y.

In the spring when the ants come up and rest in large numbers under stones over their burrows, the spiders are found among them. If not frightened they move slowly about like the ants and disappear under ground. If frightened they move much more rapidly than the ants and down into the nest or out into the surrounding grass.

Phrurolithus minutus Bks. Ithaca Spiders. Proc. Phil. Acad., 1892.

Male 2 mm. long. Abdomen covered with a hard shiny plate and strongly iridescent. Cephalothorax with a narrow light band extending back from the eyes to the dorsal groove behind this widening into a nearly square spot. Pl. VI, fig. 2. The legs are pale except the first pair, which have the tibia black with a white tip and the patella and end of the femur also black, and the second pair which have less distinctly the same markings. The palpi are dark but not black. The tibia of the male palpus has on the outer side a long slender process divided at the end into a short, square lower tooth and a long slender, sickle-shaped upper tooth. The tibia is longer than wide and the outer process starts from its basal half. Figs. 2a, 2b. On the under and inner side of the tibia is a short, blunt tooth directed forward.

Tyngsboro, Apr. 5, 1909, in open field under straw. One adult male and several immature males and females.

Phrurolithus borealis.

P. alarius (in part) Em. Trans. Conn. Acad., 1890.

Male 2 to 2.5 mm. long. Cephalothorax light in the middle and dark at the sides without any defined markings. Abdomen dark and iridescent with traces of a pattern on the hinder half. Legs 3 and 4 pale without any spots. Leg 1 has the tibia black with

a white tip and leg 2 has the same colors less strongly marked. The patella and end of the femur of leg 1 are also dark colored. The male palpus is dark colored its whole length. The tibia is as wide as long and has on the outer side, starting in the middle, a long process that widens toward the end where it is truncated obliquely and has on the upper corner a short, slightly curved tooth turned inward. Pl. VI. fig. 3, 3a.

The female is a little larger than the male, with the abdomen larger and less iridescent and with the hinder half marked with light and dark chevrons. The front half has the markings absent or indistinct and is sometimes gray and sometimes paler than the rest of the back. The epigynum has the receptacles twice their diameter apart. Under side of abdomen pale or with two faint longitudinal lines.

New Haven, Conn., Tyngsboro, Mass., Three Mile Island, Lake Winnepesaukee, N. H., Crawford Notch.

Phrurolithus alarius, Hentz.

Phrurolithus palustris Bks. Ithaca Spiders, Proc. Phil. Acad. 1892.
P. alarius (in part) Em. Trans. Conn. Acad. 1890.

This species and *borealis* were included under the name *P. alarius* Hentz in New England Drossidæ, etc. in Trans. Conn. Acad. 1890. Male and female 2 to 2.5 mm. long. The cephalothorax is pale with a black line along the edges and two dark bands extending back from the eyes and nearly meeting behind. The abdomen is marked by short lines and chevrons more or less broken into spots, especially in the female. Legs 1 and 2 have the tibia marked with black and white and legs 3 and 4 have the joints tipped with gray and a gray mark in the middle of the tibia. In pale individuals the legs are sometimes without markings, even the dark color of tibia 1 being almost absent. In very dark males the bands of the cephalothorax may be united with the black edges and the abdomen may have the markings covered with gray so as to be very indistinct. The male palpus Pl. VI, figs. 4, 4a, has the process of the tibia tapering toward the point and curved inward as figured in Trans. Conn. Acad. 1890, Pl. VI, fig. 5e and 5g. The epigynum has the receptacles not more than their diameter apart. The under side of the abdomen has usually two gray spots near the middle, one just in front of the spinnerets and others along the sides.

Around Boston Mass., Hollis, Me., Lake Winnepesaukee, N. H., south to No. Carolina.

Prothesima rufula Bks. Phil. Acad. 1892.

This is the only brown species found in New England, the others all being black or gray. A new figure is given of the male palpus, showing better the form of the palpal organ than the one in Trans. Conn. Acad. 1909, Pl. V, fig. 7. The peculiar form of the tibial hook is correct in both figures, but the tube of the palpal organ is slender and does not extend the whole length of the outer side of the tarsus.

Prothesima depressa Em. Conn. Trans. Acad., Vol. III, 1890.

Only the female was described in 1890. The males are 5 mm. long and resemble the female. The general color is black but the tarsus and metatarsus of legs 1 and 2 are pale, contrasting strongly with the black of the other joints. The legs 3 and 4 are pale with darker color toward the ends of the joints, nearly covering the tibia. The male palpi have the tarsus more pointed than in *atra*, with the tube of the palpal organ directed toward the tip. Pl. V, fig. 8c. The tibia has a process on the outer side that varies in form. In some individuals it is sharply pointed, as long as the diameter of the tarsus, and nearly straight; in others it is of the same length and curved, while in others it is short and rounded at the end and curved nearly at a right angle. Figs. 8, 8a, 8b. All these forms of the tibia have been found in specimens collected in the same place at the same time.

Blue Hills, Milton, near Boston, Mass., Three Mile Island N. H.

Prothesima transversa, new.

Male 5 mm. long. Two specimens dark-colored and one light, apparently lately molted, but neither showing the contrast between light and dark markings which is conspicuous in *depressa*. The palpi have the tarsus larger than in *depressa* and the tibia thicker, with the process straight and the tip flattened and rounded and not much curved. Pl. V, fig. 9. The palpal organ is distinctly different from that of the other species, the tube turns forward and ends in the notch at the tip of the tarsus as usual, but at its base begins a slender process nearly as long as the tube which crosses it to the outer edge of the tarsus. The basal processes of the bulb differ slightly in the different individuals, but in all are longer and more slender than in *depressa*, Figs. 9a, 9b.

Blue Hills and Middleboro, Mass., New Haven, Conn.

Dentryphantes castaneus, (Hentz), Peckham. Revision of the Attidæ of North America, Trans. Wis. Acad., 1909.

Female 6 mm. long. Cephalothorax 3 mm. The cephalothorax is covered with short gray hairs but in alcohol the whole front half appears black and the hinder half brown. The abdomen is brown with a white stripe around the front. There are fine waving black lines running irregularly lengthwise and in the middle of the hinder half a middle row of indistinct herringbone markings. In alcohol the markings are more distinct and there is none of the red color which is so evident in the other species of *Dendryphantes*. Pl. VI, fig. 5. The legs are pale with faint brown marks across the middle of the joints which are deeper colored on the patella, tibia and femur of the first legs. On the under side the legs are pale, including the coxæ and sternum, with no marking except on the front pair. The under side of the abdomen has three black stripes from the epigynum, nearly to the spinnerets and at the sides the waving black lines extend underneath. Fig. 5 a. The epigynum has a short rounded notch showing nothing distinctive.

Gloucester, Mass. in a sphagnum bog, Aug. 25, 1910. Found before by Banks in the southern states from Washington to North Carolina.

Sittacus striatus, new.

Female 5 mm. long. Male 3.5 mm. Cephalothorax in both sexes 2 mm. long. The cephalothorax is less narrowed in front and has the sides straighter than in *S. palustris*. The cephalothorax has three narrow light stripes. The markings of the abdomen are much like those of the female *Dendryphantes militaris*, the middle markings only slightly larger than the others. Pl. VI, figs. 6, 6 b. Neither specimen has the large middle light mark which is conspicuous in *palustris*. The legs are striped lengthwise, while in *palustris* they are ringed crosswise, but on the under side there are indistinct rings on the femura. The general color is light yellow-brown like straw, much lighter than the usual color of *palustris*. The male palpus has a sharp process on the outside of the tibia nearly as long as the rest of the joint, as in *palustris*, but the bulb of the palpal organ is circular while in *palustris* it always has a depression on the outer edge. Figs. 6, 6 e.

A male and female were taken in straw on a salt marsh at Plum Island, Mass., June 17 and another female in a sphagnum bog at Bangor, Me. June 30.

PLATE I

- 1 *Theridion globosum*, side of ♂. 1a cephalothorax, eyes and palpi from above. 1b sternum and palpi from below.
- 2 *Teutana grossa*, dorsal markings of ♂. 2a sternum and maxillæ.
- 3 *Pedanostethus fuscus*, base of palpal organ, 3a same of *P. pumilus*, 3b same of *P. riparius*, 3c same of *P. spiniferus*.
- 4 *Ceratinella sphaerica*, side of ♂. 4a dorsal view of ♂. 4b male palpus. 4c tibia and tarsal hook of male palpus.
- 5 *Ceratinella carinata*, tibia and tarsus of male palpus. 5a same of *C. laetabilis*. 5b same of *C. laeta*. 5c same of *C. brunneus*.
- 6 *Grammonota trivittata*, cephalothorax and palpi of ♂. 6a same of *G. ornata*. 6b male palpus of *G. trivittata*. 6c same of *G. ornata*.
- 7 *Araeoncus bispinosus*, side of cephalothorax of ♂. 7a head and palpi of ♂. 7b male palpus. 7c sternum.
- 8 *Dicymbium pectinatum*, side of cephalothorax of ♂. 8a metatarsus of first leg. 8b upper side of male palpus. 8c outer side of right palpus. 8d under side of male palpi.
- 9 *Histogramia nasuta*, cephalothorax of ♂. 9a side of cephalothorax of ♂. 9b, 9c male palpi.

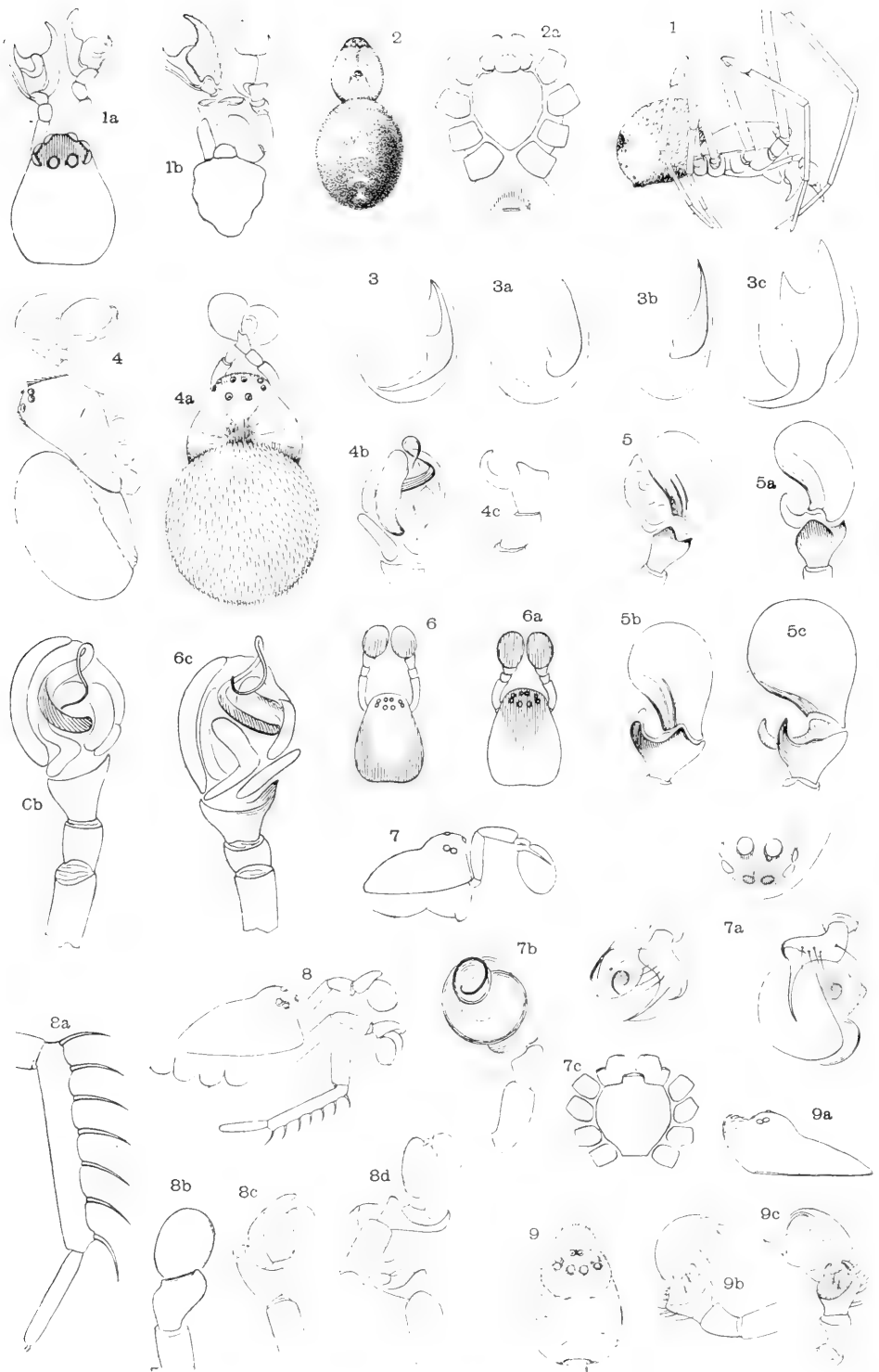


PLATE II

- 1 *Lophocarenum bilobatum*, male from above. 1a side of cephalothorax. 1b male palpus.
- 2 *Lophocarenum exiguum*, side of cephalothorax of male. 2a front of male and palpus. 2b left palpus. 2c top of head.
- 3 *Lophocarenum excavatum*, side of male. 3a head of male from in front and above. 3b male palpus. 3c epigynum.
- 4 *Lophocarenum arenarium*, dorsal view of male. 4a side of cephalothorax. 4b male palpus, outer side. 4c epigynum.
- 5 *Lophocarenum domiciliorum*, head and palpi of male. 5a side of head. 5b male palpus. 5c tibia of male palpus, inner side.
- 6 *Lophocarenum flagellatum*, head and palpi of male. 6a cephalothorax slightly turned to show grooves in head. 6b side of cephalothorax.
- 7 *Lophocarenum decemoculatum* and *florens*. 7 eyes of *decemoculatum*. 7a eyes of *florens*. 7b epigynum of *decemoculatum* 7c epigynum of *florens*.
- 8 *Lophocarenum* (*Tmeticus*) *armatum*. 8 dorsal view of cephalothorax showing pits in the head, eyes and mandibles. 8a side of cephalothorax. 8b under side of cephalothorax. 8c head and eyes of female. 8d under side of female. 8e male palpus. 8f patella of male palpus from the side. 8g front of head and mandibles of male. 8h tarsal hook and base of tarsus.

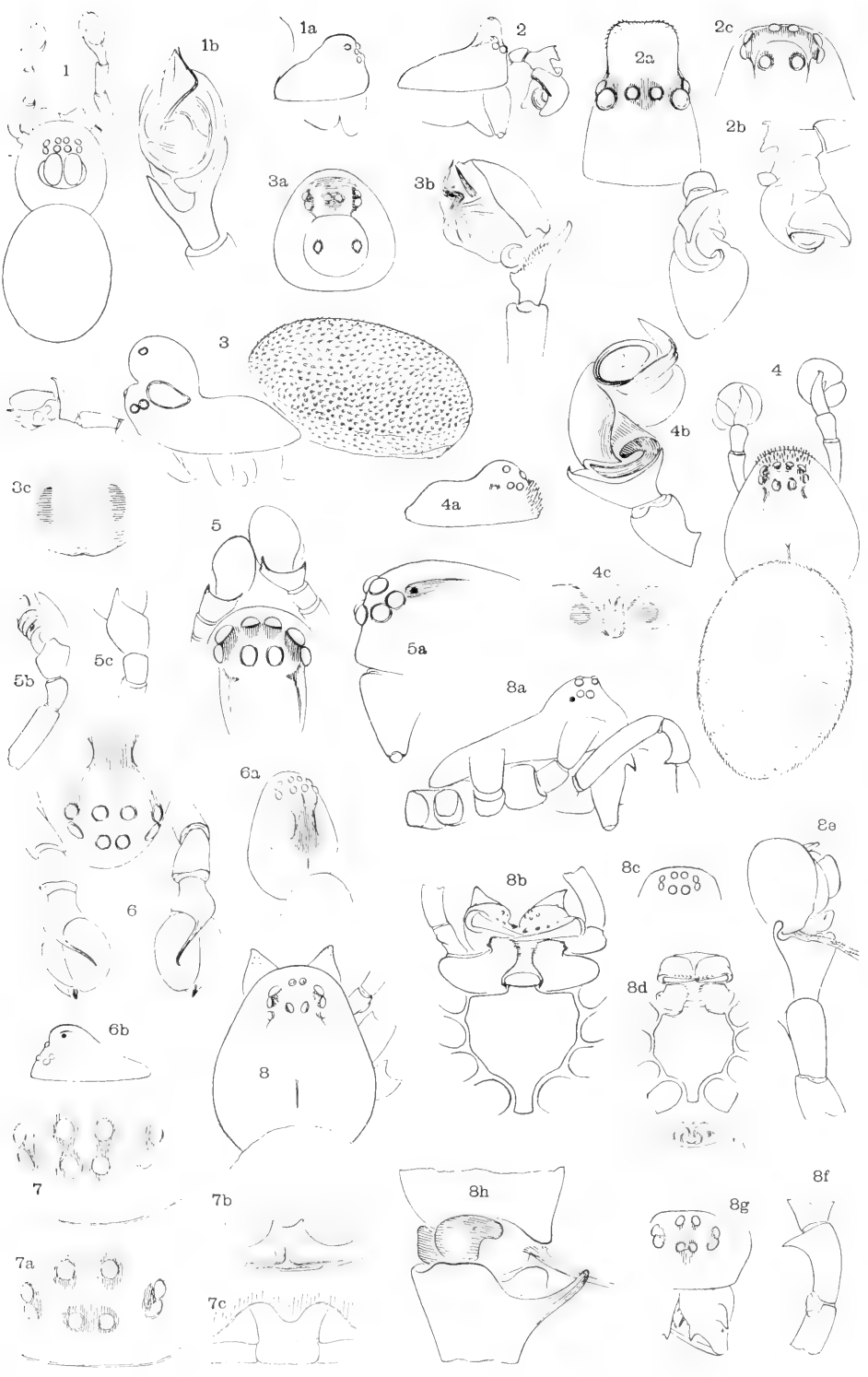


PLATE III

- 1 *Tmeticus aestivalis*, male palpi from below. 1a palpus from outer side. 1b palpus from above. 1c epigynum.
- 2 *Tmeticus tarsalis*, side of cephalothorax of ♂. 2a palpal organ. 2b male palpus showing tarsal hook and wide tarsus.
- 3 *Tmeticus entomologicus*, head and palpi of ♂. 3a male palpus from side.
- 4 *Tmeticus tenuipalpis*, side of ♂. 4a maxillæ and mandibles of ♂. 4b front of head and mandibles of ♂. 4c male palpus from below. 4d male palpus from above. 4e epigynum.
- 5 *Microneta olivacea*, cephalothorax and palpus of ♂. 5a male palpus, outer side. 5b side of cephalothorax of male. 5c side of cephalothorax of female. 5d palpus of female. 5e palpus of female from Narcross, Me., without enlarged tarsus. 5f mandible of female. 5g top of cephalothorax of female. 5h front of female showing enlarged palpi. 5i and 5k epigynum.
- 6 *Bathyphantes theridiformis*, back of male. 6a male palpus. 6b mandibles of male. 6c epigynum.
- 7 *Bathyphantes intricata*. 7, 7a, 7b, 7c, 7d male palpus.

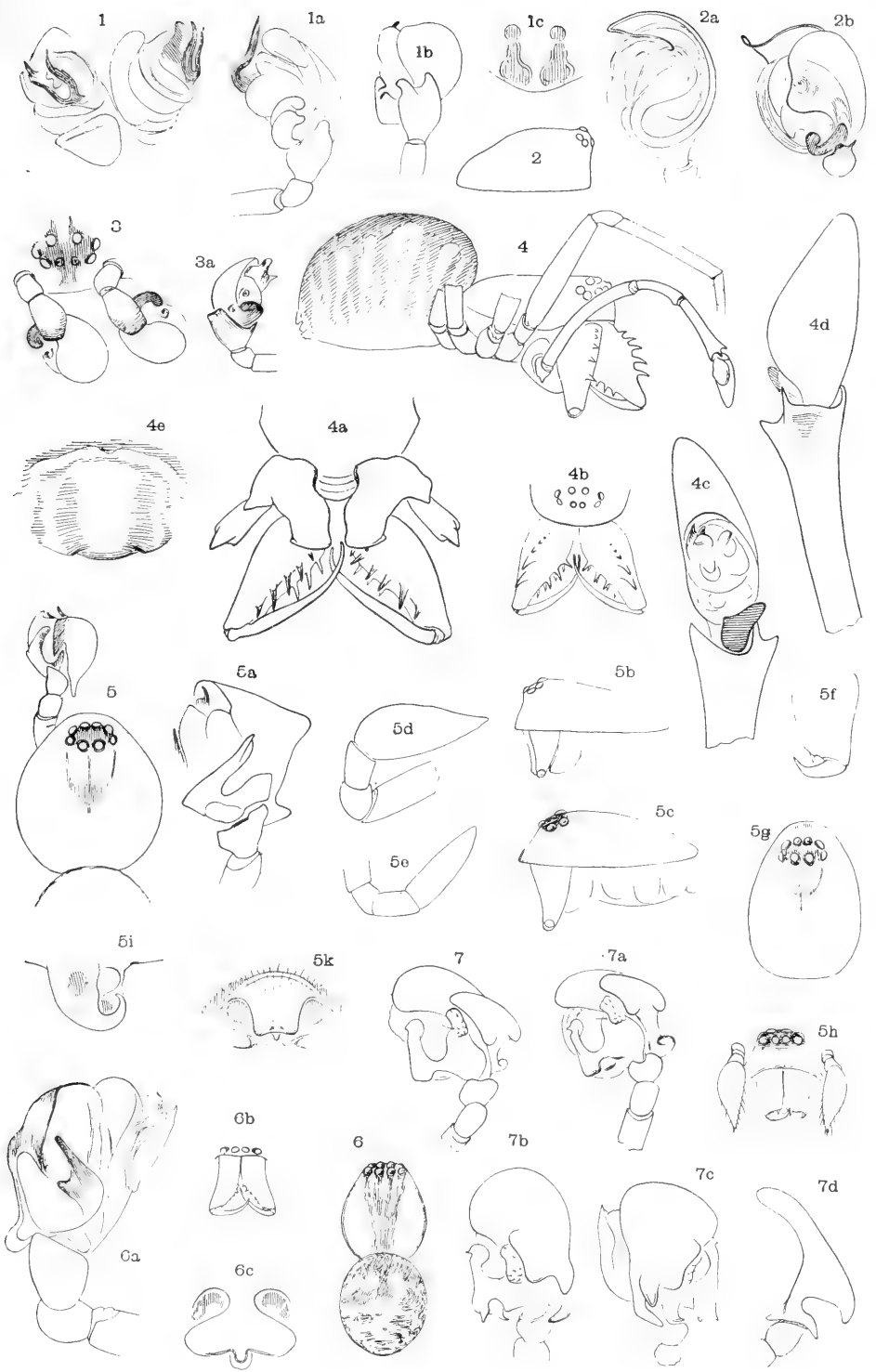


PLATE IV

- 1 *Diplostyla brevis*, outer side of male palpus. 1a under side of male palpus. 1b epigynum.
- 2 *Linyphia humilis*, front and mandibles of male. 2a top of head and palpi of male. 2b dorsal markings of female. 2c side of abdomen. 2d epigynum.
- 3 *Dictyna terrestris*, side of head and palpus of male. 3a mandibles of ♂. 3b male palpus. 3c head and palpus of male. 3d head and palpus of *D. volupis* for comparison.
- 4 *Argenna obesa*, under side of female. 4a back of female. 4b, 4c, 4d, 4e male palpus.
- 5 *Lathys foxii*, dorsal markings. 5a under side of female. 5b, 5c male palpus. 5d male palpus from above. 5e eyes.
- 6 *Pisaura brevipes*, dorsal markings and diagram showing relative length of first leg. 6a epigynum. 6b diagram showing relative length of first leg of *P. undata*. 6c epigynum of *P. undata*.

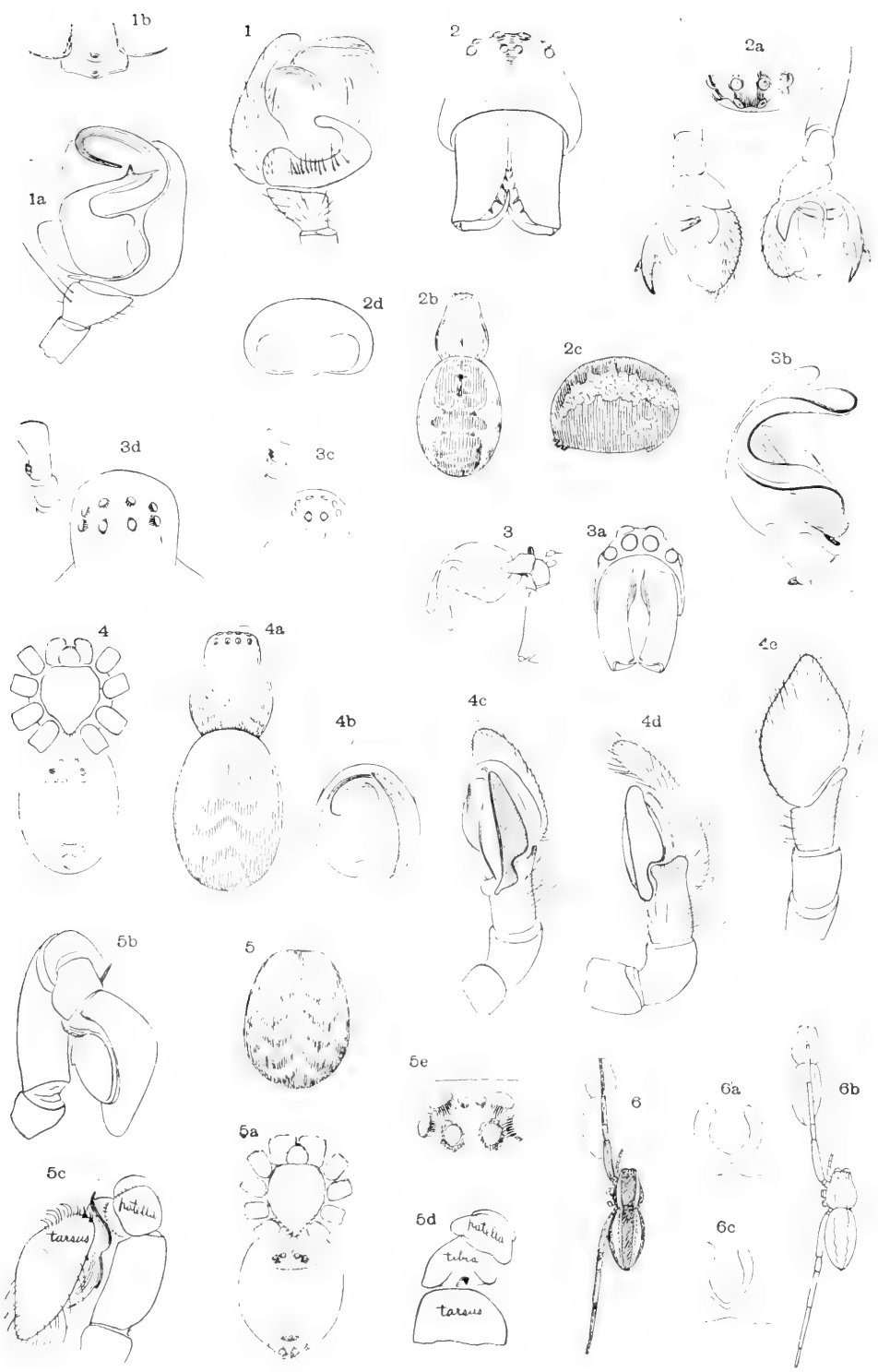


PLATE V

- 1 *Lycosa quinaria*, back of ♂ with palpus. 1a palpus of ♂ under side.
- 2 *Pardosa muscicola*, dorsal markings of ♂. 2a male palpus from below. 2b male palpus from the side. 2c epigynum.
- 3 *Pirata montana*, dorsal markings. 3a palpus of ♂, under side.
- 4 *Liocranum calcaratum*, back of ♀. 4a under side of ♀. 4b first leg of ♀ showing spines. 4c back of ♂. 4d epigynum. 4e male palpus. 4f male palpus showing palpal organ.
- 5 *Zora spinimana*, dorsal markings of ♀. 5a epigynum. 5b first leg showing spines.
- 6 *Micaria longispina*, palpal organ. 6a, 6b, palpus of ♂ showing tibial spine.
- 7 *Prosthesima rufula*, palpus of ♂.
- 8 *Prosthesima depressa*. 8, 8a, 8b three forms of tibial spine. 8c palpus of ♂ showing palpal organ.
- 9 *Prosthesima transversa*, palpus of ♂ showing palpal organ. 9a tibial spine from above. 9b tibial spine from outer side.

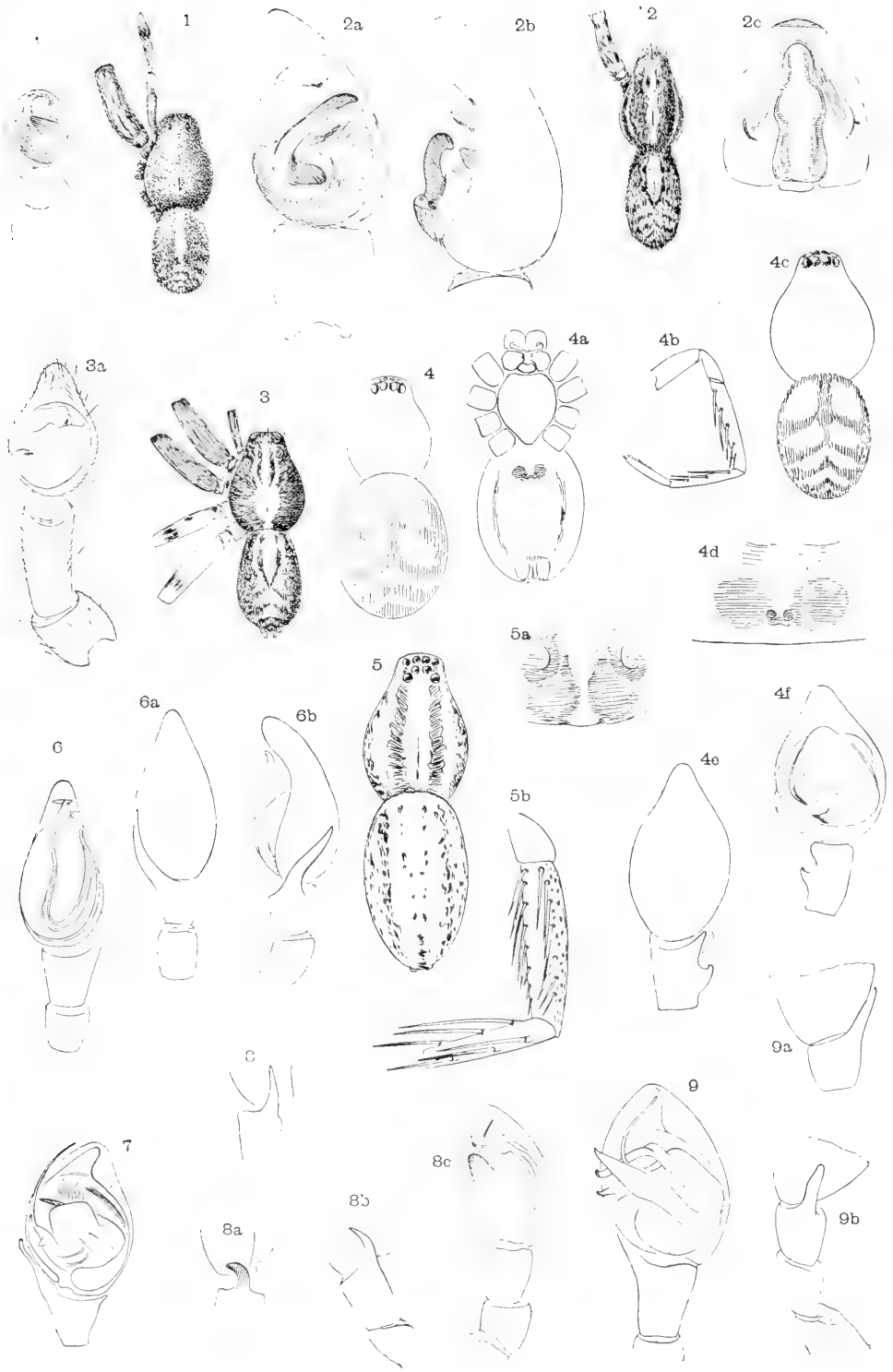
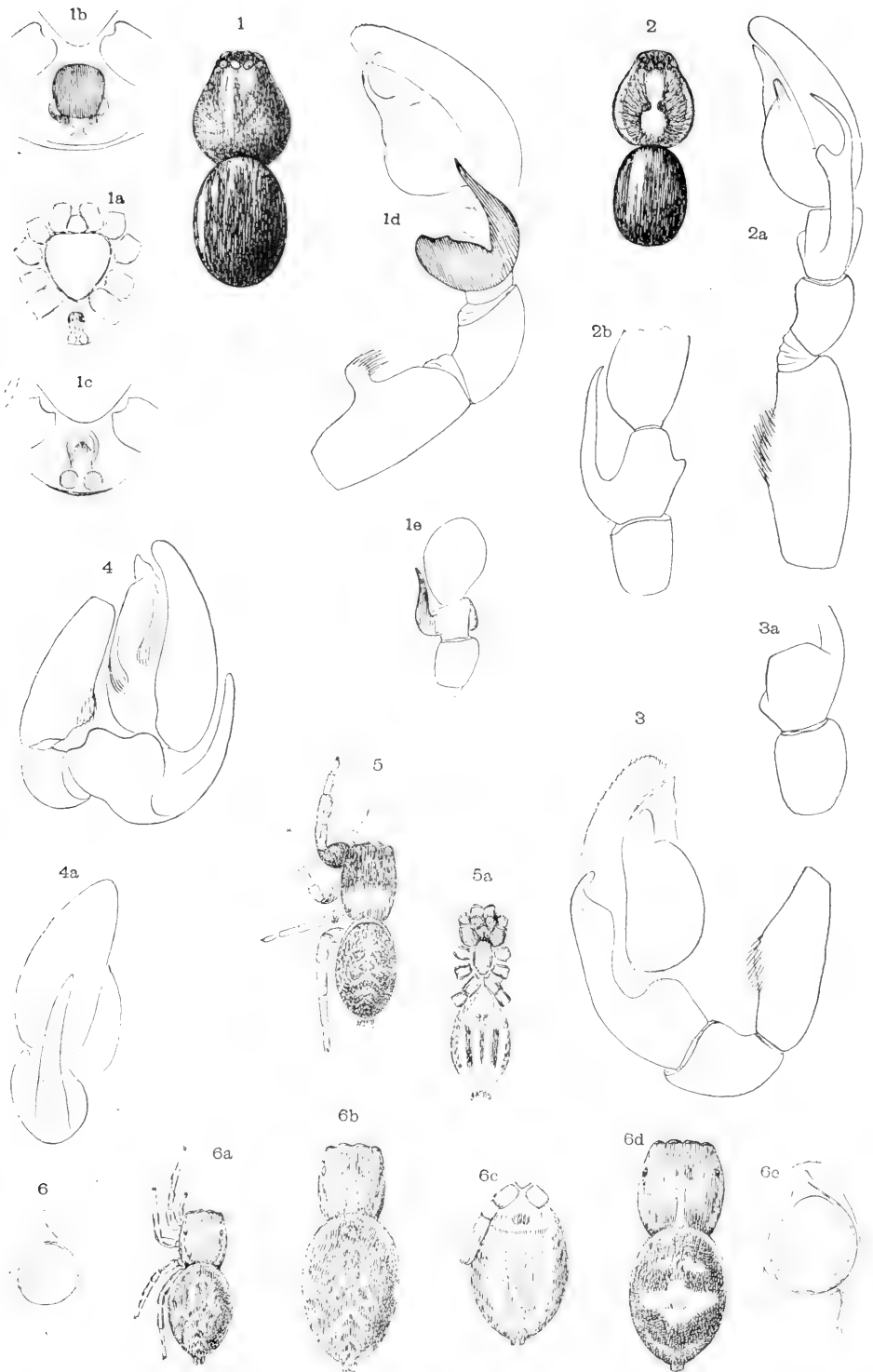
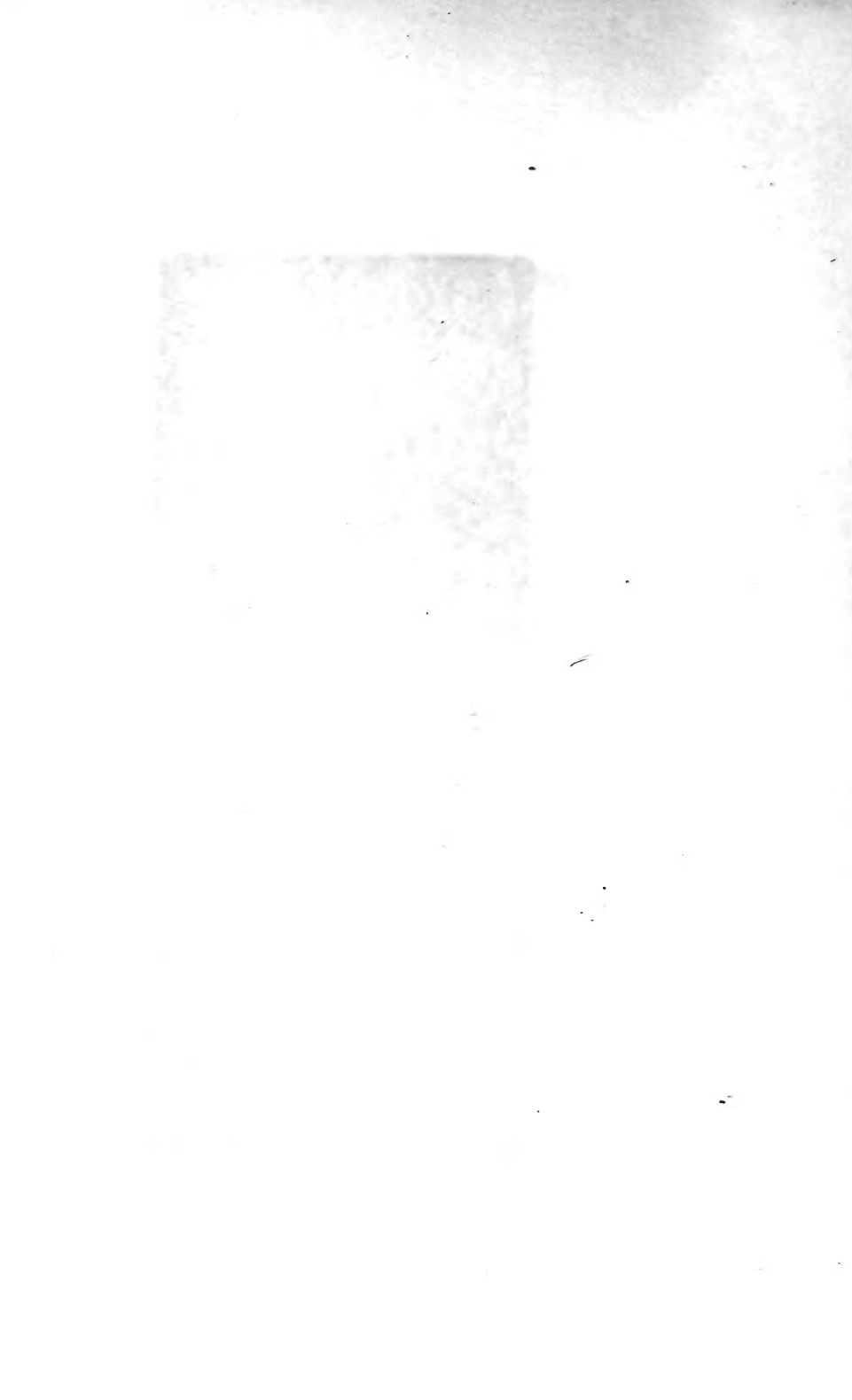


PLATE VI

- 1 *Phrurolithus formica*, back of female. 1a sternum and maxillae.
1b epigynum of old female. 1c epigynum of young female.
1d palpus of male. 1e palpus of ♂ from above.
- 2 *Phrurolithus minutus*, back of ♂. 2a palpus of ♂. 2b tarsus of
palpus from above.
- 3 *Phrurolithus borealis*, palpus of ♂, outer side. 3a tarsus of palpus.
- 4 *Phrurolithus alarius*, palpus of ♂, outer side. 4a palpus of ♂ from
above.
- 5 *Dendryphantès castaneus*, dorsal markings as they appear in al-
cohol. 5a markings of under side.
- 6 *Sittacus striatus*, palpus of ♂ showing palpal organ. 6a female
from above. 6b dorsal markings of ♀. 6c ventral markings
of ♀. 6d dorsal markings of *S. palustris*. 6e male palpus of
S. palustris.







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