STERKIANA

NO. 54 JUNE 1974

CONTENTS PAGE

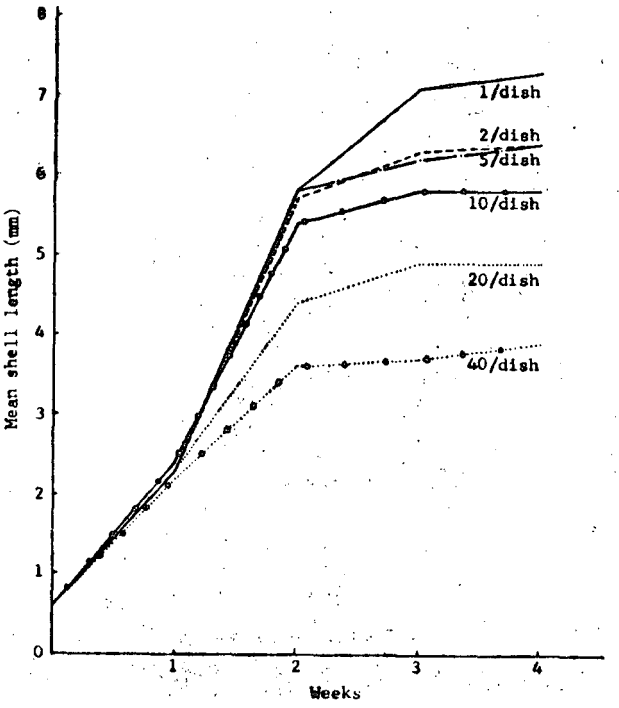

Fig. 18. Effect of crowding on mean shell length of *B. pfeifferi* reared for 4 weeks

in 525° C-heated steamed extract. Silica was highest in 525° C-heated steamed extract, less in steamed extract and lowest in stirred extract. Sulphate was highest in 525° C-heated steamed extract with 630 ppm (=680 + 580/2) and was about the same between stirred extract and steamed extract with 360 ppm and 350 ppm (=360 + 340/2), respectively. The different values for chloride, magnesium hardness, nitrate and nitrite nitrogen, pH, and phosphate appeared insignificant. In conclusion, excessive amounts of calcium, silica, sulphate, or combinations of them appear to be harmful to snail growth.

Part IV. Formulation of Synthetic Mud

Previous studies showed that mud, collected from a local natural habitat of amphibious *Pomatiopsis cincinnatiensis* snails, was suitable for growing a variety of blue-green algae which in turn, supported good growth of *Bulinus globosus* and *Biomphalaria pfeifferi* snails (as indicated in Part I and Part II). This same mud was also excellent for growing a unialgal culture of *Nostoc muscorum* which was even better than the mixture of blue-green algae for supporting growth of *Biomphalaria pfeifferi* snails (Part III).

Culture methods like these might be difficult to reproduce by those not having access to this particular type of mud, or a suitable type of mud might not be available locally if the habitat were polluted or destroyed. Therefore, the following methods were designed in an attempt to develop a synthetic mud to be substituted for the natural product.

The formulation of the various types of synthetic muds was accomplished essentially on the basis of trial and error (see Table 7 for formulae) and involved altogether 12 experiments. Some components justified for use in the earlier formulae were eliminated later because they had not shown beneficial properties. For each formula, 3 Petri dishes (Experiments 1 through 5) or 4 Petri dishes (Experiments 6 through 12) were established. Usually *Nostoc muscorum* was inoculated into the cultures immediately after the dishes were prepared. Five snails were added to each Petri dish 5 to 16 days after algal inoculation. As a rule, Petri dish preparations were not replaced during the course of these experiments. Measurements were made weekly over a 1 to 5 week period.

Experiment 1

Petri dishes were made according to the formulae shown in Table 7. Three days after algal inoculation, all the dishes emitted a strong, sour 'rotten fish' odor, apparently caused by putrefaction of the fish meal and fermentation of the glucose. Snails were, therefore, not introduced into these dishes.

Experiment 2

The amount of fish meal used in the formulae was cut to half that used in Experiment 1, and glucose was omitted. The amounts of oyster shell and bone meal used were also each reduced to half that in Experiment 1; KNO_3 was also omitted. Snails were added five days after algal inoculation and cultured for five weeks; the results are shown in Table 39. To the end of the fourth week, survivorship in the Petri dishes with distilled water as overlay (Formulae 1 and 3) was better than those with artificial water as overlay (Formulae 2 and 4). This difference, however, became insignificant by the end of the fifth week.

To the end of the second week Petri dishes with distilled water used in making paste (Formulae 1 and 2) supported shell growth better than those with BBMSU used for paste (Formulae

Table 38. Analyses of kinds of mud extracts used in Experiments 1 and 2

Tests	Kinds of mud extracts					
	Steamed extract		Stirred extract		525°C-heated steamed extract	
	Expt. 1	Expt. 2	Expt. 1	Expt. 2	Expt. 1	Expt. 2
Alkalinity (as ppm $CaCO_3$)						
Carbonate	0.0	0.0	*	0.0	0.0	0.0
Bicarbonate	65.0	75.0	*	155.0	50.0	40.0
Chloride (as ppm Cl)	45.0	50.0	*	45.0	55.0	45.0
Copper (ppm)	0.0	-	*	-	0.0	-
Hardness (as ppm $CaCO_3$)						
Total	440.0	560.0	*	640.0	960.0	840.0
Calcium	405.0	440.0	*	540.0	890.0	800.0
Magnesium	35.0	120.0	*	100.0	70.0	40.0
Iron (ppm)	0.0	-	*	-	0.0	-
Magnesium (ppm)	0.0	-	*	-	0.0	-
Nitrate & nitrite nitrogen (as ppm nitrogen)	0.080	0.063	*	0.034	0.076	0.030
pH value	7.15	7.55	*	7.40	7.25	6.95
Total phosphate	0.27	0.48	*	0.23	0.52	0.25
Silica (ppm)	52.0	50.0	*	34.0	80.0	60.0
Sulphate (ppm)	360.0	340.0	*	360.0	680.0	580.0

* = Not applicable; '-' = Not tested.

3 and 4). However, this relationship was reversed at the end of the third week. By the end of the fifth week, shell length was about the same among snails in Formulae 1 through 3, with means of 5.0, 5.2, and 5.1 mm, respectively; in Formula 4 the mean shell length was as high as 6.2 mm. Although the differences in mortality might have eventually affected the values for shell lengths among the survivors, there was an indication that Petri dishes with artificial water as overlay supported better shell growth than those with distilled water as overlay. Egg-laying occurred only in the Formula 4 Petri dishes, where altogether 32 eggs were laid at the end of the third week and 99 at the end of the fourth.

In conclusion, a workable synthetic mud was formulated. In order to culture snails to the end of the second week, either Formula 1 or Formula 2 with distilled water for pasting is recommended. To culture snails up to the end of the fifth week and for egg-production, Formula 4, BBMSU for pasting and artificial water as overlay, is recommended. On the whole, for shell growth and egg production, artificial water was always superior to distilled water as overlay.

Experiment 3

The amounts of oyster shell, bone meal and fish meal used were the same as in Experiment 1; charcoal was increased to 3 gm., and KNO_3 was added. The amount of agar used was reduced to 0.5 gm. Snails were introduced nine days after algal inoculation and were cultured for six weeks. The results are shown in Table 40.

No snails died in Formula 1 throughout the entire course of the experiment; in Formula 2, two out of 15 snails died. The difference in survivorship between these two groups may not be meaningful.

To the end of the fourth week, Formula 2 supported better growth than Formula 1, and the mean shell length was 6.2 mm versus 5.7 mm. This difference between the two formulae became insignificant by the end of the sixth week, when the shell length values were 6.5 mm and 6.4 mm, respectively. With Formula 2 egg-laying first occurred at the end of the fourth week; with Formula 1 it did not occur until the end of the fifth week. In both cases, the elapsed time for egg-laying after the snails hatched was considerably longer than observed among snails cultured previously with natural mud (see Table 33).

In conclusion, artificial water was again superior to distilled water as overlay for egg production. The artificial water was also superior to distilled water in producing shell growth at least up to the end of the fourth week.

Experiment 4

The solid components used in the formulae were similar to those used in Experiment 2 except that bone meal was omitted and the amount of agar was reduced to 0.3 gm. Snails were introduced 13 days after algal inoculation and were cultured for one week. The results are shown in Table 41. Survivorship in Formulae 1 and 2 was about the same, with 93.3% (14/15) and 100.0% (15/15) surviving; in both Formulae 3 and 4 with 80.0% (12/15) survived. The rate of growth with all of the formulae was about the same, with a mean shell length in the range of 1.1 to 1.7 mm, which was con-

Table 39. Effect of synthetic muds (in Expt. 2) on survivorship, shell length ($\bar{x}$) (mm) and fecundity of B. pfeifferi reared for 5 weeks *

Formulae **	Dish No.	Weeks 1			2			3			4			5		
		S	SL	E	S	SL	E	S	SL	E	S	SL	E	S	SL	E
1 Dis + Dis	1	5	2.5	0	5	4.7	0	5	4.7	0	5	4.9	0	5	5.0	0
	2	5	2.4	0	5	4.1	0	4	5.1	0	4	5.2	0	4	5.2	0
	3	5	2.7	0	5	4.4	0	5	4.5	0	5	4.6	0	4	4.7	0
	TM	15	2.5	0	15	4.4	0	14	4.8	0	14	4.9	0	13	5.0	0
2 Dis + Art	1	3	1.8	0	2	3.2	0	1	5.9	0	1	6.8	0	1	7.1	0
	2	5	2.8	0	5	4.3	0	5	4.3	0	5	4.5	0	5	4.6	0
	3	5	2.9	0	5	4.8	0	4	5.5	0	4	5.6	0	3	5.7	0
	TM	13	2.6	0	12	4.3	0	10	4.9	0	10	5.2	0	9	5.2	0
3 BBMSU + Dis	1	5	2.2	0	5	4.3	0	5	4.9	0	5	4.9	0	3	4.9	0
	2	5	2.0	0	5	4.2	0	5	5.1	0	5	5.2	0	3	5.2	0
	3	5	2.2	0	5	3.6	0	5	5.0	0	5	5.1	0	4	5.2	0
	TM	15	2.1	0	15	4.0	0	15	5.0	0	15	5.1	0	10	5.1	0
4 BBMSU + Art	1	3	1.6	0	3	3.5	0	2	5.9	22	2	6.4	27	2	6.6	0
	2	5	2.4	0	5	4.3	0	5	5.8	10	5	5.9	25	5	6.1	0
	3	4	1.7	0	4	3.0	0	4	5.5	0	4	5.9	47	4	6.0	0
	TM	12	2.0	0	12	3.9	0	11	5.7	32	11	6.0	99	11	6.2	0

S = No. of survivors; SL = Shell length; E = Total eggs; TM = Total and mean; * Snails were introduced 5 days after algal inoculation; ** Prototype = Clay 100 + Shell 0.5 + Charcoal 2 + Agar 2 + Bone 0.5 + Fish 0.5 (see Table 7), 1st liquid used for paste and 2nd for overlay.

Table 40. Effect of synthetic muds (in Expt. 3) on survivorship, shell length ($\bar{x}$) (mm) and fecundity of B. pfeifferi reared for 6 weeks *

Formulae **	Dish No.	Weeks 1			2			3			4			5			6		
		S	SL	E	S	SL	E	S	SL	E	S	SL	E	S	SL	E	S	SL	E
1 Dis + Dis	1	5	1.8	0	5	3.3	0	5	4.8	0	5	5.6	0	5	6.0	37	5	6.4	99
	2	5	1.9	0	5	3.3	0	5	4.7	0	5	5.9	0	5	6.2	43	5	6.3	86
	3	5	1.9	0	5	3.4	0	5	4.7	0	5	5.7	0	5	6.2	85	5	6.5	127
	TM	15	1.9	0	15	3.3	0	15	4.7	0	15	5.7	0	15	6.1	165	15	6.4	312
2 Dis + Art	1	5	2.5	0	5	4.6	0	5	5.4	0	5	5.9	0	5	6.0	40	5	6.3	48
	2	3	2.0	0	3	4.0	0	3	5.2	0	3	6.2	0	3	6.5	0	3	6.9	7
	3	5	2.5	0	5	4.7	0	5	6.0	0	5	6.5	107	5	6.5	16	5	6.6	7
	TM	13	2.4	0	13	4.5	0	13	5.6	0	13	6.2	107	13	6.3	56	13	6.5	62

S = No. of survivors; SL = Shell length; E = Total eggs; TM = Total and mean; * Snails were introduced 9 days after algal inoculation; ** Prototype = Clay 100 + Shell 1 + Charcoal 3 + Agar 0.5 + Bone 1 + Fish 1 + KNO_3 0.05 (see Table 7), 1st liquid used for paste and 2nd for overlay.

siderably smaller than found in Experiment 2, where the value over the same period was between 2.0 and 2.6 mm (see Table 39). Omitting bone meal or reducing agar, or the combination, might account for this unsuccessful attempt. However, it was certain that using modified artificial water I for pasting caused more mortality (as in Formulae 3 and 4) than when distilled water was used (as in Formulae 1 and 2).

Experiment 5

The solid components used in the formulae were the same as those in Experiment 3 but in some the amounts used differed. Charcoal was increased from 3 to 4 gm., fish meal was increased from 1 to 1.5 gm. and agar was reduced from 0.5 to 0.3 gm.; altogether 4 formulae were prepared. All Petri dishes in all formulae emitted a rotten fish smell 3 days after

Table 41. Effect of synthetic muds (in Expt. 4) on survivorship and shell length ($\bar{x}$) (mm) of B. pfeifferi reared for 1 week *

Formulae**	Dish No.	Week 1	
		No. of survivors	Shell length
1 Dis + Dis	1	4	1.3
	2	5	1.3
	3	5	1.3
	Total & Mean	14	1.3
2 Dis + Art	1	5	1.6
	2	5	1.6
	3	5	1.7
	Total & Mean	15	1.6
3 Mod Art I + Dis	1	5	1.0
	2	3	1.1
	3	4	1.2
	Total & Mean	12	1.1
4 Mod Art I + Art	1	4	1.6
	2	4	1.8
	3	4	1.7
	Total & Mean	12	1.7

* Snails were introduced 12 days after algal inoculation; ** Prototype = Clay 100 + Shell 0.5 + Charcoal 2 + Agar 0.3 + Fish 0.5 (see Table 7), 1st liquid used for paste and 2nd for overlay.

Table 42. Effect of synthetic muds (in Expt. 6) on survivorship, shell length ($\bar{x}$) (mm) and fecundity of B. pfeifferi reared for 3 weeks *

Formulae**	Dish No.	Weeks								
		1			2			3		
		S	SL	E	S	SL	E	S	SL	E
1 Prototype	1	0								
	2	0								
	3	0								
	4	0								
	TM	0								
2 No fish	1	5	2.1	0	5	4.4	0	5	5.5	8
	2	5	1.9	0	5	3.9	0	5	5.3	12
	3	5	1.9	0	5	3.8	0	5	5.8	37
	4	5	1.8	0	5	3.9	0	5	5.5	28
	TM	20	1.9	0	20	4.0	0	20	5.5	85
3 Kaolin 100 gm in place of Clay 100 gm	1	0								
	2	0								
	3	0								
	4	0								
	TM	0								
4 Sand 140 gm in place of Clay 100 gm	1	#								
	2	#								
	3	#								
	4	#								
	TM	#								

S = No. of survivors; SL = Shell length; E = Total eggs; TM = Total and mean; * Snails were introduced 12 days after algal inoculation; ** Prototype = Clay 100 + Shell 1 + Charcoal 4 + Agar 0.3 + Bone 1 + Fish 1.5 (see Table 7), in all formulae, dist. water used for paste and mod. art. water III for overlay; # All 4 dishes putrefied 3 days after algal inoculation, therefore, no snails were introduced.

algal inoculation. Since some spotty algal growth was found in all dishes, snails were introduced five days after algal inoculation. All of those snails were dead when examined one week after they were introduced. The failure of this experiment was probably due to the excessive amount of fish meal used in the formulae.

Experiment 6

This experiment was designed to test whether a synthetic mud without fish meal could support growth of snails; and whether kaolin or white sand could be substituted for pottery clay as a substrate for synthetic mud. Formula 1 was prepared so that all solid components were exactly the same as the ones found in Experiment 5, except that KNO_3 was not added. In Formula 2, fish meal was omitted. In Formulae 3 and 4, kaolin and white sand respectively were substituted for pottery clay; the alga was inoculated as usual. In Formula 4, strong rotten fish smell was evident three days after algal inoculation; no algal growth was observed. In Formula 1 and Formula 3, although the rotten fish smell was present three days after algal inoculation, spotty algal growth was still observed. In Formula 2, the algae grew nicely. Snails were, consequently, introduced 12 days after the algal inoculation to Formulae 1 through 3; they were cultured for three weeks with weekly examinations. The results are shown in Table 42.

In Formulae 1 and 3, all snails died by the end of the first week; in Formula 2, no snails died throughout the entire course of the experiment.

Growth of snails in Formula 2 was fairly good and was comparable to that in Formula 4 of Experiment 2 (see Table 39) and Formula 2 of Experiment 3 (see Table 40). At the end of the third week, the mean shell length was 5.5 mm. Egg-laying started at the end of the third week, which was, again, comparable to Formula 4 of Experiment 2.

To conclude: (a) synthetic mud without fish meal supported growth and egg production at least as well as the synthetic mud with fish meal; (b) the suitability of kaolin or white sand as substitute for pottery clay was not conclusively determined in present experiment since Formula 1, which supposedly served as control, was found not able to support

Table 43. Effect of synthetic muds (in Expt. 9) on survivorship and shell length ($\bar{x}$) (mm) of B. pfeifferi reared for 3 weeks *

Formulae**	Dish No.	Weeks 1 S	1 SL	2 S	2 SL	3 S	3 SL
1 Prototype	1	2	3.3	2	6.1	2	6.1
	2	4	3.1	4	4.0	4	4.0
	3	3	3.2	3	4.5	3	4.5
	4	3	2.8	3	3.4	3	3.5
	Total & Mean	12	3.1	12	4.3	12	4.4
2 No clay	1	0					
	2	0					
	3	2	1.7	0			
	4	0					
	Total & Mean	2	1.7	0			

S = No. of survivors; Sl = Shell length; * Algae were inoculated and snails were introduced on the same day, more algae were inoculated 4 and 7 days later; ** Prototype = Clay 100 + Shell 2 + Charcoal 3 + Agar 0.5 (see Table 7), in both formulae, art. water used for paste and overlay.

Table 44. Effect of synthetic muds (in Expt. 10) on survivorship, shell length ($\bar{x}$) (mm) and fecundity of B. pfeifferi reared for 3 weeks

Algae inoculated on day*	Formulae**	Dish No.	Weeks 1 S	1 SL	1 E	2 S	2 SL	2 E	3 S	3 SL	3 E
-14	1 Prototype (Art + Art)	1	5	3.0	0	5	5.5	48	5	5.6	119
		2	5	3.0	0	5	5.6	16	5	5.7	66
		3	5	3.1	0	5	6.0	57	5	6.0	108
		4	5	3.0	0	#					
		TM	20	3.0	0	15	5.7	121	15	5.8	293
	2 Prototype (BBM + Art)	1	5	2.2	0	#					
		2	5	2.0	0	#					
		3	5	2.0	0	#					
		4	4	2.3	0	#					
		TM	19	2.1	0	#					
	3 No clay (Art + Art)	1	0								
		2	0								
		3	0								
		4	0								
		TM	0								
	4 No clay (BBM + Art)	1	0								
		2	0								
		3	0								
		4	0								
		TM	0								

S = No. of survivors; SL = Shell length; E = Total eggs; TM = Total and mean; * Day 0 refers to the day snails were introduced; ** Prototype = Clay 100 + Shell 1 + Charcoal 3 + Agar 0.5 (see Table 7), 1st liquid used for paste and 2nd for overlay; # = Snails killed by accident.

growth because of the excessive amounts of fish meal; and (c) in Formula 4 the fish meal apparently putrefied more rapidly in the presence of sand.

Experiment 7 and Experiment 8

Survival was very erratic, with numerous deaths in formulae which were satisfactory in previous experiments. The reasons for this mortality are not known.

Experiment 9

The solid components were pottery clay, oyster shell, charcoal and agar. In order to determine the value of pottery clay, other than to serve as a substrate for algal growth, two formulae were prepared having the same constituents with the exception that Formula 2 lacked pottery clay. After introducing snails into the four Petri dishes in each of the two formulae an excessive amount of alga was added to all of the Petri dishes on days 0, 4 and 7 after snail introduction to insure immediate availability of algal food for all snails in the first week of their life. The snails were cultured for three weeks and the results are shown in Table 43.

Survivorship was good in Formula 1 in which 60% (12/20) of the snails survived throughout the 3-week period. In Formula 2, only 10% (2/20) survived to the end of the first week; and none to the end of the second week. The rate of growth was good in Formula 1, with a mean shell length of 3.1 mm at the end of the first week; this value was almost twice that in Formula 2, in which the mean shell length in the same period was only 1.7 mm.

This experiment indicated that the pottery clay was essential in Formula 1 for the growth of snails for reasons other than supporting the growth of algae. It was also evident that snails could be cultured in the absence of bone meal.

Experiment 10

The basic formula in this experiment was derived from Formula 1 of Experiment 9, but the amount of oyster shell used was reduced to 1 gm. Altogether 4 formulae, two with pottery

Table 44. Continued

Algae inoculated on day *	Formulae **	Dish No.	Weeks 1 S	1 SL	1 E	2 S	2 SL	2 E	3 S	3 SL	3 E
0, 1, 2, 3 & 4	1 Prototype (Art + Art)	1	3	2.6	0	3	4.8	0	3	4.9	0
		2	5	2.5	0	5	3.9	0	5	3.9	0
		3	5	2.6	0	5	4.4	0	5	4.4	0
		4	5	2.8	0	5	4.8	0	5	4.8	0
		TM	18	2.6	0	18	4.4	0	18	4.5	0
	2 Prototype (BBM + Art)	1	3	2.3	0	3	4.1	0	3	4.8	14
		2	5	2.2	0	5	3.7	0	5	3.7	0
		3	4	2.4	0	4	4.7	0	4	5.1	14
		4	4	2.2	0	3	5.1	0	3	5.4	34
		TM	16	2.3	0	15	4.3	0	15	4.7	62
	3 No clay (Art + Art)	1	4	1.5	0	0					
		2	3	1.5	0	1	1.7	0	1	1.8	0
		3	1	1.5	0	0					
		4	1	1.7	0	0					
		TM	9	1.5	0	1	1.7	0	1	1.8	0
	4 No clay (BBM + Art)	1	0								
		2	1	1.2	0	1	1.7	0	1	1.7	0
		3	1	1.2	0	0					
		4	0								
		TM	2	1.2	0	1	1.7	0	1	1.7	0

Table 45. Effect of synthetic muds (in Expt. 11) on survivorship of B. pfeifferi reared for 4 days *

Formulae **	Dish No.	Days 1	2	3	4
1 Prototype	1	4	4	4	0
	2	5	5	5	0
	3	5	5	4	0
	4	5	5	5	0
	Total	19	19	18	0
2 No charcoal	1	0			
	2	0			
	3	0			
	4	0			
	Total	0			

* Algae were inoculated and snails were introduced on the same day, more algae were inoculated 1, 2, 3 and 4 days later;
** Prototype = Shell 1 + Charcoal 3 + Agar 0.5 (see Table 7), in both formulae, art. water used for paste and overlay.

clay and two without pottery clay, were prepared. For each formula four Petri dishes, totaling 16 dishes, were made; algae were then inoculated. Snails were introduced 14 days later (designated hereafter as '-14 day group'). On the day of snail introduction (day 0), duplicates of the above four formulae, each still with four Petri dishes totaling 16 dishes, were made. Into these 16 dishes the snails were also introduced immediately after algal suspension, in excessive amount, was inoculated (designated hereafter as '0-1-2-3-4 group'). Snails in both the -14 group and the 0-1-2-3-4 group were cultured for three weeks. Meanwhile, more algal suspension, still in excessive amount, was repeatedly added to the 0-1-2-3-4 group on days 1, 2, 3 and 4 after the introduction of snails; the results are shown in Table 44.

Survivorship was good at the end of the first week in Formula 1 and Formula 2 of both the -14 and the 0-1-2-3-4 group, and continued to be so until the end of the third week. Unfortunately, dish 4 in Formula 1 and all of the dishes in Formula 2, all in -14 group, were accidentally destroyed. On the other hand, the survival in Formula 3 and Formula 4, regardless of whether they were from the -14 group or from the 0-1-2-3-4 group, was very poor. No snails were alive at the end of the first week in Formula 3 or Formula 4 of the -14 group. In the 0-1-2-3-4 group, only 10% (2/20 in Formula 4) to 45% (9/20), in Formula 3) of the snails survived to the end of the first week; at the end of the third week, only 5% (1/20) in each formula were alive.

Using the available data, the rate of body growth was best in Formula 1 of the -14 group, which had a mean shell length of 5.8 mm at the end of the third week. The growth in both Formula 1 and Formula 2 of the 0-1-2-3-4 group was about the same for the same period of time, giving a mean shell length of 4.5 mm and 4.7 mm, respectively. The growth in both Formula 3 and Formula 4 of the 0-1-2-3-4 group was rather poor, giving only 1.8 mm and 1.7 mm, respectively in the mean shell length for the same three-week period.

Egg-laying was first observed in Formula 1 of the -14 group at the end of the second week. This time interval was, so far, the shortest ever observed for *Biomphalaria pfeifferi* snails with either natural or synthetic mud. At the end of the third week egg-laying was also found in the Formula 2 of the 0-1-2-3-4 group.

To summarize: (a) the conclusions from Experiment 9 were confirmed, i.e., of the materials tested pottery clay was essential for the growth of snails and the snails could be cultured in a synthetic mud without the addition of bone meal; (b) inoculating algae before introducing snails was not a necessity, but it was better for snail growth (compare Formula 1 of the -14 group with Formula 1 of the 0-1-2-3-4 group); and (c) with everything else equal between 2 formulae, the use of BBM for mixing (Formula 2 of the 0-1-2-3-4 group) resulted in better body growth and egg production than the use of artificial water (Formula 1 of the 0-1-2-3-4 group).

Table 46. Effect of synthetic muds (in Expt. 12) on survivorship, shell length (SL) (mm) and fecundity of B. pfeifferi reared for 4 weeks *

Formulae **	#	Dish No.	Weeks 1 S	1 SL	1 E	2 S	2 SL	2 E	3 S	3 SL	3 E	4 S	4 SL	4 E
1 Prototype	3+	1	5	2.6	0	4	5.5	0	4	6.2	121	4	6.4	0
		2	5	3.4	0	5	5.0	0	4	5.7	0	4	5.7	0
		3	5	2.8	0	5	5.3	0	5	5.6	0	5	5.6	0
		4	5	2.9	0	5	5.3	0	5	5.5	39	5	5.5	0
		TM	20	2.9	0	19	5.3	0	18	5.5	160	18	5.8	0
2 No charcoal	3+	1	5	2.9	0	5	5.1	21	5	5.1	16	5	5.1	0
		2	5	2.6	0	5	5.0	0	5	5.2	27	4	5.4	0
		3	5	2.6	0	5	4.6	0	5	5.5	0	5	5.6	0
		4	5	2.8	0	5	4.7	1	5	4.9	9	5	4.9	0
		TM	20	2.7	0	20	4.9	22	20	5.1	52	19	5.2	0
3 No shell	0	1	5	1.5	0	4	1.7	0	0					
		2	5	1.6	0	5	1.6	0	1	4.0	0	0		
		3	5	2.0	0	5	2.0	0	3	2.2	0	0		
		4	5	1.9	0	3	1.9	0	2	1.9	0	0		
		TM	20	1.7	0	17	1.8	0	6	2.4	0	0		
4 Clay and agar only	0	1	0											
		2	0											
		3	0											
		4	0											
		TM	0											
5 No clay	2+	1	3	1.2	0	2	1.7	0	0					
		2	0											
		3	1	1.3	0	0								
		4	4	1.4	0	2	2.0	0	0					
		TM	8	1.3	0	4	1.9	0	0					

S = No. of survivors; SL = Shell length; E = Total eggs; TM = Total and mean; * Snails were introduced 16 days after algal inoculation; ** Prototype = Clay 100 + Shell 1 + Charcoal 3 + Agar 0.5 (see Table 7), in all formulae, art. water used for paste and overlay unless otherwise indicated; # = Growth of algae on day 0 (= the day snails introduced).

Table 46. Continued

Formulae **	#	Dish No.	Weeks 1 S	1 SL	1 E	2 S	2 SL	2 E	3 S	3 SL	3 E	4 S	4 SL	4 E
6 Shell and agar only	2+	1	4	1.5	0	3	2.0	0	1	2.5	0	0		
		2	0											
		3	0											
		4	0											
		TM	4	1.5	0	3	2.0	0	1	2.5	0	0		
7 Charcoal and agar only	0	1	4	1.4	0	0								
		2	0											
		3	0											
		4	1	1.5	0	0								
		TM	5	1.4	0	0								
8 Agar only	2+	1	2	1.1	0	0								
		2	0											
		3	0											
		4	2	1.2	0	0								
		TM	4	1.1	0	0								
9 Prototype (BBM + Art)	3+	1	5	2.2	0	5	4.1	0	5	5.5	102	5	5.7	121
		2	5	2.0	0	4	3.6	0	4	4.7	7	4	4.9	0
		3	5	1.7	0	4	1.9	0	3	2.2	0	2	2.6	0
		4	5	1.8	0	4	2.0	0	2	2.3	0	1	2.6	0
		TM	20	1.9	0	17	3.0	0	14	4.1	109	12	4.7	121
10 Natural mud (Dis + Dis)	3+	1	5	2.8	0	5	6.6	0	5	7.2	169	5	7.2	11
		2	5	2.7	0	5	7.0	0	5	8.0	85	5	8.0	0
		3	5	3.4	0	5	7.0	0	5	8.3	0	5	8.5	0
		4	5	3.3	0	5	7.3	0	5	7.6	137	5	7.6	0
		TM	20	3.0	0	20	7.0	0	20	7.8	391	20	7.8	11

Experiment 11

From Experiments 9 and 10 it was concluded that formulae without pottery clay did not support snail growth. As a preliminary test for the experiment that followed (Experiment 12 below), the role of charcoal in the formulae was tested without pottery clay. Formula 1 contained charcoal, and Formula 2 did not. The algal suspension, in excessive amount, was inoculated to both formulae on days 0, 1, 2, 3 and 4 after the snails were introduced. Snails were checked daily. The results are shown in Table 45.

In Formula 1 most snails survived to the end of the third day and all were dead at the end of the fourth day. With Formula 2 all snails were dead at the end of the first day. It is likely that the charcoal absorbs toxic substances from the formula.

Experiment 12

Formula 1 of Experiment 10, in which algae were inoculated 14 days before snail introduction, was found best for supporting both growth and egg production among all of the formulae tested in the previous 11 experiments. Therefore, in this experiment, this formula was used as a prototype. Based on this prototype, altogether 8 formulae (1 through 8), were designed in such a way as to determine the roles of pottery clay, oyster shell and charcoal. Formula 9 was designed to compare the efficiencies of artificial water and BBM, when both were used for mixing. Formula 10, in which natural mud was used in place of synthetic mud, served as control. In Experiment 10 it had been shown that prior algal inoculation was better than inoculation immediately after introduction of the snails. In this experiment, therefore, algae were inoculated 16

Table 47. Summary of synthetic mud formulae which support good growth of B. pfeifferi

Expt. No.	Formula No.	Synthetic muds: Solid (gm) Clay	She-ll	Char coal	Agar	Bone	Fish	KNO_3	Liquid: Paste (70 ml)	Overlay (240 ml)	Snails: S.(%) at wk 2	SL (mm) at wk 2	3	Oviposi. at wk 2	3
2	1	100	0.5	2	2	0.5	0.5	-	Dis	Dis	100	4.4	4.8	-	-
	2	100	0.5	2	2	0.5	0.5	-	Dis	Art	80	4.3	4.9	-	-
	3	100	0.5	2	2	0.5	0.5	-	BBMSU	Dis	100	4.0	5.0	-	-
	4	100	0.5	2	2	0.5	0.5	-	BBMSU	Art	80	3.9	5.7	-	+
3	1	100	1	3	0.5	1	1	0.05	Dis	Dis	100	3.3	4.7	-	-
	2	100	1	3	0.5	1	1	0.05	Dis	Art	87	4.5	5.6	-	-
6	2	100	1	4	0.3	1	-	-	Dis	Mod Art III	100	4.0	5.5	-	+
9	1	100	2	3	0.5	-	-	-	Art	Art	60	4.3	4.4	-	-
10	A-1	100	1	3	0.5	-	-	-	Art	Art	75	5.7	5.8	+	+
	B-1	100	1	3	0.5	-	-	-	Art	Art	90	4.4	4.5	-	-
	B-2	100	1	3	0.5	-	-	-	BBM	Art	75	4.3	4.7	-	+
12	1	100	1	3	0.5	-	-	-	Art	Art	95	5.3	5.6	-	+
	2	100	1	-	0.5	-	-	-	Art	Art	100	4.9	5.1	+	+
	9	100	1	3	0.5	-	-	-	BBM	Art	85	3.0	4.1	-	+

S = Survivorship; SL = Shell length; A = -14 group; B = 0-1-2-3-4 group.

days before snail introduction; the snails were cultured for four weeks and the results are shown in Table 46.

Survival was good in Formulae 1, 2, 9 and 10, with all snails alive at the end of the first week; at the end of the fourth week, the survival was 90% (18/20), 95% (19/20), 60% (12/20) and 100% (20/20), respectively. The rate of growth was also good in these formulae, with mean shell lengths of 5.8 mm, 5.2 mm, 4.7 mm and 7.8 mm, respectively, at the end of the fourth week. The poor survival and growth in Formulae 3 through 8 indicate that elimination of oyster shell or pottery clay was detrimental.

The algal growth in the present experiment was closely related to snail growth. In other words, luxuriant algal growth was correlated with better snail growth.

Egg-laying was first observed in Formula 2 at the end of the second week and it was of the same magnitude as found in one of the formulae in Experiment 10 (see Table 44, Formula 1 of -14 group). By the end of the third week, egg-laying had started in Formulae 1, 9 and 10.

From this experiment the following conclusions are made: (a) synthetic mud, composed of pottery clay, oyster shell, charcoal and agar and mixed with artificial water to form a paste and using the same kind of water as overlay (as Formula 1) was found suitable for snail growth and egg-laying; (b) omission of charcoal from the formula did not affect the rate of growth to a great extent (compare Formulae 1 and 2), in fact the start of egg-laying might be enhanced by the absence of charcoal; (c) omitting oyster shell was harmful to both survival and rate of shell growth (compare Formulae 1 and 3); (d) pottery clay and agar alone did not support the snails (compare Formulae 1 and 4); (e) formulae without pottery clay did not sustain the snails (Formulae 5 through 8); and (f) for mixing, artificial water was superior to BBM in supporting the survival and rate of growth, but the BBM was, in turn, superior to artificial water in terms of fecundity of snails (compare Formulae 1 and 9).

For convenience the formulae in which the survivorship of the snails was 60% or more and the mean shell length was 3.0 mm or more at the end of the second week are listed in Table 47. Altogether 14 formulae were involved. Formula A-1 of Experiment 10 (and the identical Formula 1 of Experiment 12) and Formula 2 of Experiment 12 were found most promising.

DISCUSSION

Part I. The Effect of Crowding on Survivorship, Growth and Fecundity

Although the growth and fecundity of schistosome snail vectors have been studied by many workers, suitable methods for culturing *Bulinus globosus* and *Biomphalaria pfeifferi*, both important African intermediate vectors, are difficult to find. There are only a few workers who have studied the growth and fecundity of these two species of snails intensively (Shiff, 1964a, 1964b; Sturrock, B.M., 1966 and Sturrock, R. F., 1966). A few other workers have found these snails rather difficult to maintain in laboratory cultures (Jennings *et al.*, 1970 and Lo, 1972). Methods undertaken with the use of trays now indicate that those snails can quite easily be cultured in the laboratory provided certain care is exercised.

1. *Bulinus globosus*

As judged by survivorship, the present tray method appears to be promising. With four different population densities, *i.e.*, 5-, 10-, and 40-snails per tray, there was 80% to 100% survivorship over an eleven-week period (Table 8). These values are 20 to 40% higher than the highest value obtained by Shiff (1964a) who cultured the same species of snails in large tanks with six snails or less per tank. While more detailed comparison with his work will be discussed later (Part II), it suffices to state that this tray method stimulates earlier and greater egg production and the snails have larger shells.

With respect to body growth, there was a definite trend toward reduced growth with an increase in individual variation of shell size as the snails became more crowded (Table 8 and Fig. 2). At the same time fecundity was also adversely affected under conditions of crowding (Table 9 and Fig. 3). Shiff (1964b) indicated that *Bulinus globosus* snails at a density of one snail per liter of water showed optimum body growth. The optimum number of snails in the present investigation depended on the avowed purpose of the culture.

For obtaining good survivorship and body growth, the method using five snails per tray during the later weeks in culture is recommended, since survivorship was highest and the shell length was largest. In practice, one can start 40 newly hatched snails in a tray culture; at the end of the second week the snails (about 2.4 mm long) can be placed in 4 trays with 10 snails per tray. After the fourth week these snails (now about 5.5 mm) can be rehoused in eight trays with five snails per tray. Following the sixth week, the snails (about 8.2 mm) would then be mature.

To obtain good egg-laying, the method using 10 snails per tray during the later weeks is recommended. While it was shown that the number of eggs laid per snail in 10 snails per tray was smaller than in trays with five snails per tray, the total yield of eggs in the former was considerably greater. A density of 20 snails per tray or 40 snails per tray is not recommended either for growing snails or for egg production. Most eggs were laid on or under lettuce leaves (Table 10); the significance of this pattern will be discussed in Part II.

2. *Biomphalaria pfeifferi*

The tray method was excellent for culturing this species also. After the initial rearrangement of the cultures by the end of the second week none of the snails died during the entire period. As with *Bulinus globosus*, reduced growth rate and increased individual size variation were observed as the snails became more crowded (Table 11 and Fig. 4). With this same species Sodeman (1970) reported that stunting did not affect the start of egg production in any of the populations he tested with 7, 14, 35 and 55 snails per tank. In the present study, however, the start of egg-laying in the group with 40 snails per tray occurred one week later than the remaining groups, with 5, 10 and 20 snails per tray (Table 12). The differences observed were probably due to the larger size of the tank used by Sodeman; it was big enough not to became a growth limiting factor. The tray used in the present study was relatively small and it became a limiting factor with 40 snails in it. The small number of eggs produced also showed that adverse conditions existed because of crowding (Table 12 and Fig. 5).

Again the optimum number of snails to be accommodated in one tray depends on the purpose of the culture. If the snails are to be grown faster and to a larger size they should be cultured using five snails per tray at the very beginning of the culture, since density effects appear as early as the end of the second week. Although in these cultures growth rate decreased as density increased, body growth with either the 10-, 20- or 40-snail groups still surpassed the size obtained by Sturrock, B.M. (1966) and Sturrock, R.F. (1966).

For purposes of obtaining more eggs, the

snails should be cultured at a density of ten snails per tray. It might be argued that, since all of the energy available in a tray was about the same, the total yield of eggs from one tray should be similar to snother regardless of the number of snails present. Results shown in Table 12 indicate that this was not the case. A simple multiplication shows that the total numbers of eggs produced in trays with five snails per tray were 10,360 (2,072 X 5); 10 snails, 12,820 (1,282 X 10); 20 snails, 10,960 (548 X 20); and 40 snails 9,000 (225 X 40). One might argue that these calculations did not consider the differences in the time when egg-laying started (between the third and fourth week for 5-, 10- and 20-snail groups, but the fourth and fifth week for the 40-snail group). Recalculating and counting from the fifth week showed that the results were essentially the same, *i.e.*, 10,200 (2,040 X 5), 12,680 (1,268 X 10), 10,880 (544 X 20) and 9,000 (225 X 40), respectively. Consequently there was no question but that a density of 10 snails per tray was best for egg production; the 20-snail group was next, followed by the 5-snail group; and the 40-snail group showed the smallest in egg production. In this instance most eggs were laid on the walls of the trays (Table 13), and the significance of this observation is discussed in Part II.

Najarian (1960b) in his study of *Bulinus truncatus* found that differences in the volume of water per snail did not affect the mean number of eggs per egg-mass laid. However, Chernin and Michelson (1957a) found that with *Biomphalaria glabrata* the more crowded the snails the fewer the eggs per egg-mass. In the present study with *Biomphalaria pfeifferi* it was also observed that the more crowded the snails in a tray, the smaller the mean number of eggs per egg-mass (Table 14 and Fig. 6).

Wright (1960), working with *Bulinus forskalii*, and Webbe (1962a) with *Biomphalaria sudanica tanganyicensis* (Smith), found that the number of eggs per egg-mass increased as the parent snails became older. Similar results were obtained by Sturrock, B. M. (1966) with *Biomphalaria pfeifferi* kept individually in 250 ml of dechlorinated tap water in crystallizing dishes; the number of eggs per egg-mass increased from about 6.1 to 12.5 during the eighth to thirtieth week period. In the present study the data also show that the number of eggs per egg-mass increased as the snails aged. From the start of egg-laying up to 12 weeks in age, the number increased in the 5-snail group from 6.5 to 18.8; in the 10-snail group from 6.4 to 16.2; in the 20-snail group from 6.1 to 11.1; and in the 40-snail group from 3.9 to 8.1 (Table 14 and Fig. 7).

Part II. The Effect of Types of Waters on Survivorship, Growth and Fecundity

A. Culturing Snails in Deionized, Distilled or Spring Water

1. *Survivorship and Growth*

As shown in Table 15, the survivorship of *Bulinus globosus* was apparently not affected by the types of waters used since the percentage of the snails surviving at the end of the forty-fourth week was 73.3% (11/15) in all three types of waters used. The survivorship of *Biomphalaria pfeifferi* was also unaffected by the types of waters used, except that those in spring water showed lower survivorship (Table 19). As to the rate of body growth, there seemed no significant differences among snails in the types of waters tested, as shown for both the *Bulinus globosus* and the *Biomphalaria pfeifferi* groups (Tables 15 and 19). When the growth curves for both species were compared with those given by Shiff (1964b) and Sturrock, B.M. (1966) some significant differences appeared. The snails in the present study always completed logarithmic phases earlier and grew bigger than the snails reported by those investigators. Presumably in the present investigation enough substances, both organic and inorganic, were seeping from the mud mounds into the overlying water, whatever the type of water—deionized, distilled, tap or spring. Thus, the types of waters used were not crucial for the snails as far as their survivorship and body growth were concerned. Again, it was confirmed that the tray method was promising.

2. *Fecundity*

The fecundity of *Biomphalaria pfeifferi* and especially of *Bulinus globosus* were greatly affected by the types of waters used. As shown in Table 16 and Fig. 9, the number of eggs produced by *Bulinus globosus* in distilled water was always twice or more than that produced by those in spring water. A similar pattern, though with a less significant difference, was also observed in egg production of *Biomphalaria pfeifferi*, as shown in Table 20 and Fig. 11. Those observations imply that the spring water used was exerting some negative effects on egg production. Harrison *et al.* (1970) also found egg-laying rates with *Biomphalaria pfeifferi* were lower when they were cultured in hard waters.

While the numbers of eggs produced by *Bulinus globosus* in tap water were somewhere be-

tween those in distilled water and spring water, the number produced by *Biomphalaria pfeifferi* was highest in this same kind of tap water for egg-laying was distilled water with *Bulinus globosus* and tap water with *Biomphalaria pfeifferi*. Harrison and Shiff (1966) and also Williams (1970a, 1970b) found that the chemical composition of the water exerted a profound influence on *Bulinus globosus* and *Biomphalaria pfeifferi*. They found that *Bulinus globosus* was present in water bodies throughout the whole range of the hardness, but the populations were denser in the medium hard water; *Biomphalaria pfeifferi*, on the other hand, was restricted to medium and hard waters. The data in the present study essentially confirm the results just mentioned. When distilled water overlies the mud mound, it could be considered a medium water; tap water over the mud mound would be hard water. Spring water over the mud mound would then be 'superhard' water. Therefore, the latter was not suitable even for *Biomphalaria pfeifferi*.

The reasons for the way the hardness of the water affects the number of eggs laid are not clear. It is possible that with *Bulinus globosus* distilled water may somehow change the texture of the lettuce, the algae, or both, in such a way as to render them more easily ingested by snails, thus providing more food materials to produce eggs. On the other hand, with *Biomphalaria pfeifferi* it is possible that a change in texture of these foods as brought about by tap water was more easily ingested and thus more nutritional for egg production.

Shiff (1964a, Table 2, 25° C) reported that the number of eggs laid per *Bulinus globosus* snail was 1,032 over a 44-week period; in the present study with distilled, tap and spring waters over the 44-week period the values were 4,480, 3,391 and 2,053, respectively (Table 16). With *Biomphalaria pfeifferi*, Sturrock, R.F. (1966, Fig. 2, 25° C) reported the number of eggs laid per snail was about 930 over a 29-week period; in the present study with deionized, distilled, tap and spring waters over the same 29-week period these values were 3,949, 4,111, 4,764 and 3,465, respectively (Table 20). These results imply that the tray method provided even better conditions for reproduction.

3. Sites of egg-laying

In Part I of this dissertation it was mentioned briefly that *Bulinus globosus* laid most eggs on or under lettuce leaves when those snails were cultured with spring water; *Biomphalaria pfeifferi* laid most eggs on the walls and bottoms of the trays when they were cultured in tap water. These findings are supported by the data in Tables 17 and 21, which strongly indicate that the types of waters used significantly influenced the sites used for egg-laying with both *Bulinus globosus* and *Biomphalaria pfeifferi* snails. In distilled or deionized water most eggs were laid on the wall and bottom of trays; in tap water only a modest number were laid on these sites, and in spring water the smallest number were deposited there.

These differences in fecundity and in the sites of egg-laying, together with the information obtained from water analyses (Table 18), all suggest that water hardness plays an important role in culturing snails, especially in their reproductive potential.

B. Culturing Snails in Trays while Alternating the Types of Waters

For some time it was known that snails maintained in aquaria had distinct preferences for certain egg-laying sites and that the egg output was lowered under unfavorable conditions (Barlow and Muench, 1951; Standen, 1951; Olivier and Haskins, 1960; Olivier *et al.*, 1962; Shiff, 1964c; and Pellegrino and Gonçalves, 1965). Coles (1970) showed that the egg-laying behavior with three species of *Biomphalaria* in laboratory was related to the environment from which these snails originated. He found that 90% of the egg-masses laid by *Biomphalaria sudanica* were deposited on floating plastic; with *Biomphalaria pfeifferi* it was only 49%; with *Biomphalaria choanomphala* all egg-masses were found on the bottom of the bowls. The *B. sudanica* came from swamp water where the egg-masses would be subjected to anaerobic conditions if they were not laid close to the surface; the *B. pfeifferi* came from a rocky stream with only small amounts of floating vegetation; and the *B. choanomphala* originated from gravel beds at the bottom of the lake, where higher plants were absent for the deposition of egg-masses.

In the present study it was found that the percentages of eggs laid on a particular site varied according to the types of waters used. Both *Bulinus globosus* and *Biomphalaria pfeifferi* laid most of their eggs on the walls and bottoms of the containers when they were maintained in distilled water or deionized water; they laid fewest eggs on these sites when they were in spring water; in tap water the number of eggs laid on these sites varied from experiment to experiment (Tables 22, 23 and 24). Reasons for these differences are not clear. Presumably the sites for egg-laying were governed by a behavior pattern like that advocated by Standen (1949 and 1951). He noticed that snails did not lay eggs on any substance likely to decay before the normal egg incubation period is completed. For example, they oviposited on raw lettuce but not on cooked lettuce. In distilled water the low

concentration of ions caused the lettuce to decay more readily, and the snails then had no choice but to lay their eggs on the wall or bottom of the container. With spring water the high concentration of ions prevented the lettuce from decaying. Consequently, the snails had a choice and could select the sites they preferred. Since the site underneath lettuce leaves was relatively secluded, the snails seemed to prefer laying their eggs there. In tap water, the ion concentration fluctuated, presumably due to the fact that the water came from several sources, and the degree of lettuce decay thus also fluctuated. In this case, the percentages of eggs laid on the container wall and bottom also fluctuated.

C. Culturing Snails in Calcium, Magnesium, or Calcium-magnesium Water

Essentially this study repeats the work described in 'A' above except that waters were used with known amounts of the chemicals, calcium and magnesium. It appeared that neither calcium water nor magnesium water had any adverse effect on the survivorship of *Bulinus globosus* or *Biomphalaria pfeifferi* snails, since none died during the experimental periods. Similarly, neither the calcium water nor the magnesium water affected the rate of growth in *Bulinus globosus* snails (Table 25 and Fig. 12). With *Biomphalaria pfeifferi* the calcium water may have had some adverse effects as judged by the data found in Table 28 and Fig. 14.

Egg-laying, on the other hand, was strongly affected by the types of waters used with both *Bulinus globosus* (Table 26 and Fig. 13) and *Biomphalaria pfeifferi* (Table 29 and Fig. 15). In both cases, calcium water was found to be responsible for reducing egg production. Harrison *et al.* (1966) observed that high ratios of magnesium-to-calcium (12.4 to 1) significantly lowered the egg-laying potential of *Biomphalaria pfeifferi*. The magnesium water at the concentrations tested, however, did not show any adverse effect on the egg-laying of the snails in the present study.

The reasons for the reduction in egg-laying in calcium water were not clear. The possibility remains that calcium ions might somehow change the texture of the algae or lettuce, or both, so that they were less easily consumed by the snails, so that the snails in calcium water had less food for egg production.

As to the sites of egg-laying, both *Bulinus globosus* and *Biomphalaria pfeifferi* showed similar behavior patterns in that they laid fewest eggs on the container when they were in calcium water and most of their eggs on that same site when they were in magnesium water (Tables 27 and 30). The reasons for these differences in egg-laying sites were probably similar to those given in 'B' above, *i.e.*, calcium water somehow hardened the lettuce leaves, and the snails selected the lettuce for egg-laying. In the waters without calcium the lettuce decayed quickly, and the snails had to lay their eggs on the container walls or bottoms.

Part III. The Effect of Various Species of Algae and Various Kinds of Muds and Mud Extracts on the Growth of *Biomphalaria pfeifferi*

A. Culturing Snails in Unialgal Preparations

Very few investigators have deliberately inoculated algae into snail cultures and those who did generally used the filamentous blue-green alga *Oscillatoria* sp. This alga at times was found harmful to the snails. In the present study, with all of the blue-green algae and diatoms tested survivorship was found generally to be fair to excellent (Table 31). Such authors as Malek (1958), Gohar and El-Gindy (1962) and Webbe (1962b) considered that it was the quantity of blue-green algae and diatoms, rather than the quality that was important for conditioning the habitats of snails; also the snail density and the sizes of individuals were correlated directly with the amount of food available. In the present study it is shown that the kinds of algae used did affect the rate of growth, at least when the algae were young, as in the 10-day and 14-day groups in Table 31. From Table 31 it is clear that any one of the two pure blue-green algae, *i. e.*, *Nostoc muscorum* or *Fischerella ambigua*, supported snail growth better than did the mixture of blue-green algae.

B. Culturing Snails in Various Kinds of Tray and Petri Dish Preparations

Wright (1960) considered that at least three factors were involved in stunting of snails—food, collisions and chemical reaction due to 'pheromones.' In the present study, although no snails were found stunted in any of the cultures tested, there were, nevertheless, significant differences among snails, as shown in Table 32 and Figures 16 and 17. The fact that the snails in the *Nostoc muscorum* cultures were larger than those found in the mixture of blue-green algae was probably due to the higher nutritional value of the former. It is also presumed that the addition of lettuce was an improvement because it might

provide additional nutrition for snails in the production of more eggs. The fact that larger snails were found in trays, as compared to Petri dishes, however, could not be interpreted as simply a food factor since no more alga or lettuce was provided in trays than in Petri dishes. It would appear that the collision and pollution factors were more likely involved in terms of the differences between trays and Petri dishes, since in the former there was 1,500 ml of water per tray with a surface area of about 600 cm^2 while in the latter there was only 60 ml of water per Petri dish with a surface area of only about 60 cm^2. Webbe (1962a, 1962b, 1965) recommended the use of mean growth curves to designate the probable age of snails collected in the field. The results of present study indicate that the size of snails should not be used indiscriminately as a criterion for estimating their age. It is quite possible that sizes of snails having the same age and collected from two localities might be very different merely because of differences in the kinds of algae they were consuming.

As to fecundity, more eggs were found in trays than in Petri dishes. Presumably, there was more space available for egg deposition when trays were used. *Nostoc muscorum* was also found better than the mixture of blue-green algae, probably because of its higher nutritional value. The effect of lettuce on the fecundity of snails, however, was not significant (Table 33). Besides, it may be suspected that the presence of lettuce in some way delays the start of oviposition, since snails in two out of three trays supplied with *Nostoc muscorum* (without lettuce) began to lay eggs after two to two and one half weeks, but none in the trays supplied with *Nostoc muscorum* with lettuce did so during the same period of time (Table 33). To conclude, lettuce enhanced body growth but inhibited egg-laying.

Pereira and Deslandes (1954) and Perlowagora-Szumlewicz (1958) found that snail size correlated better with the onset of egg-laying than with snail age. However, Ritchie *et al.* (1963a) found that the size at the onset of egg-laying varied with the growth rate, *i.e.*, a rapidly growing snail reached a larger size before laying eggs than a snail that grew slowly. The data in the present study agree with this observation of Ritchie *et al.* For example, according to the normal growth curve, as shown in Fig. 10, the shell lengths of two-week old snails in trays with *Nostoc muscorum* with or without lettuce and in Petri dishes with *Nostoc muscorum* with or without lettuce were all large enough for oviposition; however, none laid eggs until the end of two and one half or three weeks (Tables 32 and 33).

C. Culturing Snails under Crowded Conditions

The observations here (Table 35) are similar to those found in Part I (see Table 11). Although a direct comparison between these two studies is not appropriate because of differences in their designs, it is possible to verify that present results appear far better than those obtained in Part I.

From the fact that the shell lengths at the end of the first week were about the same among all six different density groups tested, as seen in Table 35, it appeared that there were no limiting factors exerting effects on the growth of snails during the first week. During the second week there were still no limiting factors in the 1-, 2- and 5-snail groups. In the 10-, 20- and 40-snail groups, however, the alga appeared to be the limiting factor for growth of snails, since the growth rate among those groups slowed down immediately or soon after the alga was consumed. During the third week period, factor(s) other than algae were added and played a more important role in snail growth. This is based on two observations: (a) although there was still enough alga left in the two-snail group up to the end of the fourth week, and there was none left in the five-snail group at the end of the second week, the shell lengths in the two groups were almost identical; and (b) both the one-snail group and the two-snail group had enough alga until the end of the fourth week, yet the shell length in the one-snail group was considerably greater than that in the two-snail group (Table 35). One could thus speculate that either waste product(s) or 'pheromone-like' substance(s) might be involved.

Based on data given in Table 35 and Fig. 18, a practical way for culturing snails is proposed. Snails could be first cultured in Petri dishes with 40 snails per dish. At the end of the first week, they could be thinned out so that only five or 10 snails remained in each dish. At the end of the second week, the snails would have reached a size (5.4 mm or 5.8 mm) such that they could be harvested for experiments or placed in culture for egg-laying.

D. Culturing Snails in Various Kinds of Muds and Mud Extracts

Observations in the first experiment indicated that the presence of organic substances in mud (natural mud, steamed mud or 100° C-dried mud) was necessary for the normal

growth of snails regardless of whether alga was inoculated before snail introduction (Table 36, -10 group) or afterwards (Table 36, 0-3-11 group). Body growth, however, was always found to be better in the former than in the latter. In mud without organic substances (such as 525 Cºheated steamed mud) or an extract with insufficient amounts of organic substances (such as steamed extract), repeated addition of the alga on days 0, 3 and 11 after snail introduction was found better than adding alga only once, 10 days before snail introduction (Table 36). The second experiment (Table 37) essentially repeated the first one, but a few more preparations were tested. On the basis of the results from these two experiments and from the chemical analyses (Table 38), the following hypothesis was constructed:

Natural mud contained some organic and inorganic substances needed for algal growth, but in excess amounts it exhibited some negative effects on snail growth. Through steaming or stirring, some of these excessive substances were extracted. Consequently, it was reasonable to assume that both extracts supported algal growth and hence snail growth in part. Steamed mud or stirred mud, in turn, also appeared to contain ingredients that produced optimum growth of the alga, hence of the snails.

Similarly, the 100° C-dried mud also contained the same excessive amounts of those harmful substances as the natural mud did; therefore, it also supported snail growth to about the same magnitude as the natural mud. Through heating at 525° C, the excessive amounts of substances, as well as some other substances which may originally have been bound tightly to soil particles and were harmful to snail growth, became more water-soluble so that the snails were not able to grow at all in the Petri dishes made up with this 525° C-heated mud. Through extraction by steaming, these hypothetical harmful substances were then transferred to the 525° C-heated steamed extract. This may explain why the 525° C-heated steamed mud partially supported snail growth but the 525° C-heated steamed extract did not. When this steamed extract, which presumably contained some harmful substances, was combined with 100° C-dried mud, as in Table 37, the latter acted as a buffer to absorb some of these harmful substances. Consequently, Petri dishes with this combination only supported growth of snails moderately.

If the above hypothesis is plausible, however, it remains rather difficult to explain why the 525° C-heated steamed mud in Table 37 did not support snail growth at all, since the similar preparation in Table 36 did support the growth of snails to a certain extent. It would also be rather difficult to explain why the Petri dishes with only half-strength 525° C-heated steamed extract, as shown in Table 37, did not support snail growth. At this dilution, the concentrations of calcium, silicon, sulphate, or a combination were about the same as, or even less than, those found in steamed extract or stirred extract (Table 38), both of which had, as previously mentioned, partially supported snail growth.

Part IV. The Formulation of Synthetic Mud

As previously mentioned, other investigators have observed the importance of algae for culturing snails. Some also tried semi-synthetic foods for this purpose. Still others tried an axenic medium. However, there have not previously been any attempts to grow algae on a formulated, synthetic mud which could serve as a medium on which to culture snails. The method reported here was accomplished essentially on the basis of trial and error. Various components, both solid and liquid, were tried. Finally, two simple formulae (Formula 1 in the -14 group in Table 44 and the identical Formula 1 in Table 46; and Formula 2 in Table 46) were most promising. The former consisted of pottery clay, oyster shell, charcoal and agar; the latter used pottery clay, oyster shell and agar. In both formulae artificial water (of known chemical compositions) was used for making a paste and as an overlay. The roles played by each component are described as follows:

1. Pottery Clay

This clay was used as a basis for the synthetic muds in all 12 experiments. In the absence of the clay none of the cultures were able to sustain snails (Tables 43, 44 and 46). The speculation that the clay was important to the snails primarily by way of supporting the algal growth, which in turn supported snail growth, was rejected since repeated addition of the alga into cultures without clay still appeared ineffective for snail growth (Tables 43 and 44). On the other hand, the clay plus agar alone also did not support the growth of the alga nor, consequently, of the snails (Compare Formula 1 and Formula 4 in Table 46). Therefore, it was assumed that the primary importance of clay was mechanical rather than nutritional, as also advocated by Pan (1958), that is, to assist in grinding ingested food.

2. Oyster Shell

This was used in all 12 experiments on the chance that it might furnish substrates

for the formation of snail shells. In the absence of oyster shell none of the cultures supported the growth of the alga nor, consequently, of the snails (compare Formula 1 and Formula 3 in Table 46). Oyster shell plus agar alone did support to a moderate degree the algal growth but was still unable to support snail growth (compare Formula 1 and Formula 6 in Table 46). It appeared very likely that oyster shell was important primarily for enhancing algal growth.

3. Charcoal

The primary purpose of adding charcoal to the synthetic mud was to absorb some of the harmful waste products produced during the culturing process; it was also used in all 12 experiments.

Wright (1960) suspected that charcoal might be responsible for the poor increase in shell size among *Bulinus forskalii* snails. In the present study with all of the other components present, the absence of charcoal was not critical. In fact, it appeared advantageous for the snails, since they laid eggs earlier (compare Formula 1 and Formula 2 in Table 46). In cultures without pottery clay, on the other hand, the absence of charcoal was harmful to the snails (compare Formula 1 and Formula 2 in Table 45; and Formula 1 and Formula 6 in Table 46). Charcoal plus agar alone did not support algal growth, hence snail growth suffered (compare Formula 1 and Formula 7 in Table 46).

The reasons for these observations are not clearcut. It may well be possible that with a high calcium content (as the charcoal was made from crushed bone) there were harmful conditions for egg production, and egg-laying was inhibited; but because of its porous structure charcoal was useful in absorbing waste product(s), and it then prolonged the life of the snails.

4. Agar

Preliminary observation indicated that pottery clay needed some sticky substance to make a more solid texture, which would be important for promoting better movement of snails, especially in the first few days of life. Accordingly, agar was added in all 12 experiments. The agar itself might also act as a source of carbohydrate food for snails. In the present study the agar alone did support a moderate degree of algal growth, but it did not support snail growth at all (compare Formula 1 and Formula 8 in Table 46). To explain the effect of agar, Stiglingh and van Eeden explained that the agar was too slippery and caused the snails either to topple over or to slide backward as they fed. It was likely that the snails were dying from exhaustion.

5. Artificial Water

Distilled water did not contribute to algal growth. Other kinds of water were thought suitable for algal growth, but they were harmful for snail growth. The ingredients of artificial water were somewhat in between and contained substances which contributed to algal growth but were not harmful to snail growth.

While the above five components proved to be necessary in preparing the synthetic mud, some other components which seemed justified earlier in the experiments were discarded later for lack of beneficial effects.

In conclusion, the efficiency of these synthetic muds was still inferior to the natural mud, but its use opens a promising field for further study.

SUMMARY

The laboratory culture of the snail intermediate hosts *Bulinus globosus* and *Biomphalaria pfeifferi*, of African schistosomiasis, has up to now been very uncertain and difficult. This study aims to give simpler, more efficient, more dependable and more easily reproducible culture methods. Included also is information which provides a better understanding of the ecological requirements of these snails.

Part I

The optimum number of snails which can be accommodated in one tray (7.5 X 20 X 30 cm), along with the mixture of blue-green algae and lettuce which served as food, was investigated. Within the range studied crowding of snails did not affect their survivorship significantly. Growth, however, was affected by crowding. As the density increased, the sizes of snails became smaller and less uniform. Egg-laying likewise was affected by the crowding, and no eggs were laid in the most crowded groups.

The optimum number of individuals to be accommodated in one tray was determined. For best growth five snails per tray is recommended,

since the shell length was greatest at this density. In terms of egg-laying the use of 10 snails per tray is recommended, since total egg production in the 10-snail trays was highest.

Part II

The effects of deionized water, distilled water, tap water and spring water on survivorship, growth and fecundity of snails were measured. The work was undertaken using a mixture of blue-green algae and lettuce as food.

Survivorship of *Bulinus globosus* over 44 weeks was not affected by the types of waters (distilled, tap and spring) used. Likewise survivorship of *Biomphalaria pfeifferi* over 33 weeks was not affected in deionized, distilled or tap water but was reduced in spring water.

As for growth, there were no significant differences among the types of water tested in both species of snails.

Egg-laying was greatly affected by the types of waters used. With *Bulinus globosus* over the 44-week period the largest number of eggs were laid in distilled water, a moderate number in tap water and the smallest in spring water. With *Biomphalaria pfeifferi* during a 33-week period the results were slightly different: the largest number of eggs were laid in tap water; a moderate number in both deionized water and distilled water; and the smallest in spring water.

A comparison with the results of other investigations reveals that the present tray method is efficient both for snail growth and egg production.

The percentages of eggs laid on the container wall and bottom were also closely related to the kinds of waters used. Both species of snails laid the largest number of eggs on the container when kept in distilled water or deionized water; they laid the smallest number of eggs on the container when in spring water. In tap water, this egg-laying pattern was intermediate. Experimentally altering the types of waters used in the trays showed that these particular behaviors of egg-laying were definite in pattern. Differences in ion concentrations in the types of waters used were presumably responsible for the differences observed in egg-laying sites.

When three kinds of waters, calcium, magnesium and calcium-magnesium were tested, none of them had adverse effects on snail survivorship. Similarly these waters did not affect the growth of *Bulinus globosus* snails; with *Biomphalaria pfeifferi*, the calcium water may have had some adverse effect. Egg-laying, on the other hand, was strongly affected by these three kinds of waters used. With both species of snails, data indicate that the smallest number of eggs was found in calcium water; the largest in magnesium water; and only a moderate number in calcium-magnesium water. Likewise, the percentages of eggs laid on the container wall and bottom were closely related to the kinds of waters used. Calcium ions appear to affect the number of eggs laid as well as the egg-laying sites.

Part III

The effects of various kinds of algae and various kinds of mud and mud extracts on the growth of *Biomphalaria pfeifferi* were studied. Three species of blue-green algae *(Nostoc muscorum, Schizothrix calcicola,* and *Fischerella ambigua)* and one species of diatom *(Nitzschia frustulum)* were isolated from the mixture of blue-green algae which had been used exclusively in Part I and Part II above. Among them, *Nostoc muscorum* and *Fischerella ambigua* were both found better than the mixture of blue-green algae for supporting the snail growth. In later experiments *Nostoc muscorum* was used exclusively, because it was very easily grown in Petri dish preparations.

The efficiencies of tray and Petri dish preparations were compared. In general, the trays supported growth better than Petri dishes except when a mixture of blue-green algae with lettuce was used as food. *Nostoc muscorum,* either alone or combined with lettuce, was always better than the mixture of blue-green algae with lettuce. The beneficial effect of additions of lettuce appeared as early as the end of the second week in trays; in Petri dishes, however, this effect was not observed until the end of the third week. To conclude, best growth was observed in trays with *Nostoc muscorum* and lettuce; second best in trays with *Nostoc muscorum* but no lettuce; third in Petri dishes with *Nostoc muscorum* but no lettuce; and poorest in trays or Petri dishes with the mixture of blue-green algae and lettuce.

The optimum number of snails to be accommodated in a Petri dish was studied with *Nostoc muscorum* as the only food. Altogether six different population densities, 1, 2, 5, 10, 20 and 40 snails per dish, were tested. None of the snails died in the first three groups over the four-week period. In the last three groups over the same time period, the survivorship ranged from 63.3 to 96.7%.

With regard to the growth of snails, the shell lengths were about the same among all six groups measured at the end of the first

week. At the end of the fourth week, however, the shell length decreased as the population size increased. The possibility of the alga and waste products as the limiting factors on snail growth is discussed.

Egg-laying took place in 1-, 2-, 5- and 10-snail groups before the end of the fourth week. No eggs were found in any of the dishes with 20 and 40 snails.

A practical way of culturing *Biomphalaria pfeifferi* in Petri dishes with *Nostoc muscorum* was developed. With this method the snails were ready for harvesting at the end of the second week.

The effects of various kinds of mud and mud extracts on snail growth were studied. Organic substances in mud, such as those found in natural mud, steamed mud and 100° C-dried mud, were found essential for normal snail growth. When these muds were used, the results were always better in the groups in which the alga was inoculated once ten days before the snails were introduced and in the groups in which the alga was repeatedly inoculated after snail introduction.

In the mud with no organic substances (such as 525o C-heated steamed mud) or extract with an insufficient amount of organic substances (such as steamed or stirred extract), repeated inoculation of the alga after snail introduction was found to be better than the inoculation of alga once 10 days before snail introduction.

The 525° C-heated mud and 525° C-heated steamed extract did not support the growth of snails at all.

It is concluded that the natural mud contained substances needed for algal growth, but in excessive amounts there were some negative effects on snail growth. Heat treatment of the mud at 525° C appears to release harmful substances otherwise firmly bound in the soil particles.

Part IV

A formulation of synthetic mud was attempted; two simple formulae were found most promising. One is composed of pottery clay, oyster shell, charcoal and agar in the ratios of 100 : 1 : 3 : 0.5; the other is a mixture of pottery clay, oyster shell and agar in the ratios of 100 : 1 : 0.5. Both formulae use an artificial water for making the paste and as an overlay.

The roles played by each component remain speculative. In the absence of the pottery clay, none of the cultures sustained snails. Presumably the presence of clay was important to the snails in grinding ingested food. In the absence of oyster shell, none of the cultures supported algal growth nor, consequently, snail growth. The absence of charcoal was not critical provided that the three other components (pottery clay, oyster shell and agar) were all present. The main purpose of the charcoal was to absorb some of the water products accumulated in the cultures. Agar was important since it solidified the synthetic mud so as to give the snails a firm substrate, important for feeding. The artificial water provided some of the chemicals contributed to algal growth but were not harmful to snail growth.

For efficiency, the synthetic mud was still inferior to natural mud, but it does open a promising field for further study.

LITERATURE CITED

ALVES, W. (1958) Chemical constituents of surface water in Southern Rhodesia, with special reference to the molluscan vectors of bilharziasis. -- Bull. Wld. Hlth. Org. 18: 1071

BARLOW, C. H. (1937) The value of canal clearance in the control of schistosomiasis in Egypt. -- Amer. J. Hyg. 25: 327-348

BARLOW, C. H. & MUENCH, H. (1951) Life span and monthly mortality rate of *Bulinus truncatus* and *Planorbis boissyi*, the intermediate hosts of schistosomiasis in Egypt. -- J. Parasit. 37: 165-173

BERRIE, A.D. (1968) Prolonged inhibition of growth in a natural population of the freshwater snail *Biomphalaria sudanica tanganyicensis* (Smith) in Uganda. -- Ann. Trop. Med. Parasit. 62: 45-51

BERRIE, A.D. (1969) Factors affecting growth and reproduction of freshwater Planorbidae in East Africa. -- Malacologia 9: 35-36

BERRIE, A.D. (1970) Snail problems in African schistosomiasis. -- Adv. Parasit. 8: 43-96

BERRIE, A. D. & VISSER, S.A. (1963) Investigations of a growth-inhibiting substance affecting a natural population of freshwater snails. -- Physiol. Zoöl. 36: 167-173

BITAKARAMIRE, P. K. (1968) *Lymnaea natalensis* laboratory culture and production of *Fasciola gigantica* metacercariae. -- Parasitology 58: 653-656

BOLD, H. C. (1967) A laboratory manual for plant morphology. -- Harper & Row, New York, Evanston, and London, 87-88

BOYCOTT, A.E. (1936) The habitats of freshwater Mollusca in Britain. -- J. Anim. Ecol. 5: 116-186

CHERNIN, E. (1957a) A method of securing bacteriologically sterile snails (*Australorbis glabratus*). -- Proc. Soc. Exp. Biol. Med. 96: 204-210

---- (1957b) Studies on the control of schistosome-bearing snails. VII. Streptomycin-induced inhibition of growth and reproduction in the schistosome-bearing snail, *Australorbis glabratus*. -- Amer. J. Hyg. 66: 321-330

---- (1959) Cultivation of the snail, *Australorbis glabratus*, under axenic conditions. -- Ann. N.Y. Acad. Sci. 77: 237-245

---- (1960) Infection of *Australorbis glabratus* with *Schistosoma mansoni* under bacteriologically sterile conditions. -- Proc. Soc. Exp. Biol. Med. 105: 292-296

---- (1963) Observations on hearts explanted *in vitro* from the snail *Australorbis glabratus*. -- J. Parasit. 49: 353-364

---- (1967) Behavior of *Biomphalaria glabrata* and of other snails in a thermal gradient. -- J. Parasit. 53: 1233-1240

---- & MICHELSON, E. H. (1957a) Studies on the biological control of schistosome-bearing snails. III. The effect of population density on growth and fecundity in *Australorbis glabratus*. -- Amer. J. Hyg. 65: 57-70

---- & ---- (1957b) Studies on the biological control of schistosome-bearing snails. IV. Further observations on the effects of crowding on growth and fecundity in *Australorbis glabratus*. -- Amer. J. Hyg. 65: 71-80

----, ---- & AUGUSTINE, D.L. (1956) Studies on the biological control of schistosome-bearing snails. I. The control of *Australorbis glabratus* populations by the snail *Marisa cornu-arietis*, under laboratory conditions. -- Amer. J. Trop. Med. Hyg. 5: 297-307

CHERNIN, E. & SCHORK, A.R. (1959) Growth in axenic culture of the snail, *Australorbis glabratus*. -- Amer. J. Hyg. 69: 146-160

CHU, K. Y., MASSOUD, J., & SABBAGHIAN, H. (1966a) Host-parasite relationship of *Bulinus truncatus* and *Schistosoma haematobium* in Iran. 1. Effect of the age of *B. truncatus* on the development of *S. haematobium*. -- Bull. Wld. Hlth. Org. 34: 113-119

----, ----, & ---- (1966b) Host-parasite relationship of *Bulinus truncatus* and *Schistosoma haematobium* in Iran. 2. Effect of exposure dosage of miracidia on the biology of the snail host and the development of the parasites. -- Bull. Wld. Hlth. Org. 34: 121-130

CLAUGHER, D. (1960) The transport and laboratory culture of snail intermediate hosts of *Schistosoma haematobium*. -- Ann. Trop. Med. Parasit. 54: 333-337

COLES, G. C. (1970) Egg laying behaviour in *Biomphalaria*. -- Trans. Roy. Soc. Trop. Med. Hyg. 64: 794-795

COLTON, H.S. (1908) Some effects of environment on the growth of *Lymnaea columella* Say. -- Proc. Acad. Nat. Sci. Philadelphia 60: 410-448

COWPER, S.G. (1946) Some notes on the maintenance and breeding of schistosome vectors in Great Britain, with special reference to *Planorbis guadaloupensis* Sowerby. -- Ann. Trop. Med. Parasit. 40: 163-170

DECHANCÉ, M. & DESCHIENS, R. (1955) Action des sels de fer sur les mollusques vecteurs des bilharzioses. -- Bull. Soc. Path. Exot. 48: 470-473

DE MEILLON, B., FRANK, G.H., & ALLANSON, B. R. (1958) Some aspects of snail ecology in South Africa. A preliminary report. -- Bull. Wld. Hlth. Org. 18: 771-783

DESCHIENS, R. (1954a) Mécanisme de l'action léthale de *Cypridopsis hartwigi*, sur les mollusques vecteurs des bilharzioses. -- Bull. Soc. Path. Exot. 47: 399-401

---- (1954b) Incidence de la minéralisation de l'eau sur les mollusques vecteurs des bilharzioses. Conséquences pratiques. -- Bull. Soc. Path. Exot. 47: 915-929

----(1957a) Les facteurs conditionnant l'habitat des mollusques vecteurs des bilharzioses leurs incidences épidémiologiques. IV. Cons-

tantes physiologiques de la reproduction et particularités en fonction des espèces. Conclusions. -- Ann. Inst. Pasteur 93: 153-167

---- (1957b) Sur la perpétuation des élevages des mollusques vecteurs des bilharzioses à l'obscurité. -- Bull. Soc. Path. Exot. 50: 229-233

---- & ADETONAH, A. (1969) Conditions d'élevage de *Bulinus (Pyrgophysa) forskalii* au laboratoire. -- Bull. Soc. Path. Exot. 62: 1096-1101

DESCHIENS, R. & BIJAN, H. (1956) Comportement d'élevages de mollusques vecteurs des bilharzioses à l'obscurité. -- Bull. Soc. Path. Exot. 49: 658-661

DeWITT, R. M. (1954) Reproductive capacity in a pulmonate snail *(Physa gyrina* Say). -- Amer. Naturalist 88: 159-164

ERICKSON, D. G., RITCHIE, L. S. & CALDWELL, D.R. (1961) Growth and reproduction of *Australorbis glabratus* fed alginated food. -- J. Parasit. 47 (Sec. 2): 50

ETGES, F. J. & RITCHIE, L. S. (1966) Comparative observations on growth rate and reproduction of *Australorbis glabratus* in field and laboratory conditions. -- Bull. Wld. Hlth. Org. 34: 963 -966

EVELAND, L. K. & RITCHIE, L. S. (1972) Infectivity of cercariae of *Schistosoma mansoni* from snails on inadequate diets. -- Parasitology 64: 441-444

FORBES, G. S. & CRAMPTON, H. E. (1942) The effects of population density upon growth and size in *Lymnaea palustris*. -- Biol. Bull. 83: 283-289

FRANK, G. H. (1963) Some factors affecting the fecundity of *Biomphalaria pfeifferi* (Krauss) in glass aquaria. -- Bull. Wld. Hlth. Org. 29: 531-537

GAZZINELLI, G., RAMALHO-PINTO, F. J., PELLEGRINO, J. & GILBERT, B. (1970) Uptake of ^{59}Fe as a tool for study of the crowding effect in *Biomphalaria glabrata*. -- Amer. J. Trop. Med. Hyg. 19: 1034-1037

GOHAR, H. A. F. & EL-GINDY, H. I. (1962) Food of snail vectors of bilharziasis and Fascioliasis. -- J. Egypt. Med. Asso. 44: 976-982

GORDON, R. M., DAVEY, T. H. & PEASTON, H. (1934) The transmission of human bilharziasis in Sierra Leone, with an account of the life-cycle of the schistosomes concerned, *S. mansoni* and *S. haematobium*. -- Ann. Trop. Med. Parasit. 28: 323-418

HARRISON, A. D. (1966) The effects of Bayluscid on gastropod snails and other aquatic fauna in Rhodesia. -- Hydrobiologia 28: 371-384

---- (1968) The effects of calcium bicarbonate concentration on the oxygen consumption of the fresh-water snail *Biomphalaria pfeifferi* (Pulmonata: Planorbidae). -- Arch. Hydrobiol. 65: 63-73

----, NDUKU, W., & HOOPER, A. S. C. (1966) The effects of a high magnesium-to-calcium ratio on the egg-laying rate of an aquatic planorbid snail, *Biomphalaria pfeifferi*. -- Ann. Trop. Med. Parasit. 60: 212-214

HARRISON, A. D. & RATTRAY, E. A. (1966) Biological effects of molluscicide in natural waters. -- S. Afr. J. Sci. 62: 238-241

HARRISON, A. D. & SHIFF, C. J. (1966) Factors influencing the distribution of some species of aquatic snails. -- S. Afr. J. Sci., 62: 253-258

HARRISON, A. D., WILLIAMS, N.V. & GREIG, G. (1970) Studies on the effects of calcium bicarbonate concentrations on the biology of *Biomphalaria pfeifferi* (Krauss) (Gastropoda: Pulmonata). -- Hydrobiologia 36: 317-327

HARRY, H. W. & ALDRICH, D. V. (1958) The ecology of *Australorbis glabratus* in Puerto Rico. -- Bull. Wld. Hlth. Org. 18: 819-832

HARRY, H. W. & CUMBIE, B.G. (1956a) The relation of physiography to the types of fresh-water environments and the presence of *Australorbis glabratus* (Say) in Puerto Rico. -- Amer. J. Trop. Med. Hyg. 5: 742-756

---- & ---- (1956b) Stream gradient as a criterion of lotic habitats suitable for *Australorbis glabratus* in Puerto Rico. -- Amer. J. Trop. Med. Hyg. 5: 921-928

HARRY, H.W., CUMBIE, B.G. & MARTINEZ de JESUS, J. (1957) Studies on the quality of fresh waters of Puerto Rico relative to the occurrence of *Australorbis glabratus* (Say). -- Amer. J. Trop. Med. Hyg. 6: 313-322

HOGG, J. (1854) Observations on the development and growth of the water-snail *(Limneus stagnalis)*. -- Trans. Micro. Soc. London 2: 91-103 (appeared in Quar. J. Micro. Sci. 2).

HOPF, H. S. & MULLER, R. L. (1962) Laboratory breeding and testing of *Australorbis glabratus* for molluscicidal screening. -- Bull. Wld. Hlth. Org. 27: 783-789

HUBENDICK, B. (1958) Factors conditioning the habitat of freshwater snails. -- Bull. Wld. Hlth. Org. 18: 1072-1080

JENNINGS, A. C., De KOCK, K.N. & van EEDEN, J. A. (1970) An evaluation of five different kinds of experimental freshwater snail food. -- Wetenskaplike Bydraes van die P.U. vir. C. H.O. Reeks B: Natuurwetenskappe, nr 29: 1-14

JOBIN, W.R. & MICHELSON, E.H. (1967) Mathematical simulation of an aquatic snail population. -- Bull. Wld. Hlth. Org. 37: 657-664

JOY, J.E. (1971) The influence of light conditions upon the egg-laying of the planorbid snail, *Biomphalaria glabrata*. -- Nautilus 85: 43-49

KENDALL, S. B. (1953) The life-history of *Limnaea truncatula* under laboratory conditions. -- J. Helminth. 27: 17-28

KINOTI, G. (1968) Observations on the infection of bulinid snails with *Schistosoma mattheei*. I: The susceptibility of *Bulinus africanus* and *Bulinus truncatus*. -- Ann. Trop. Med. Parasit. 62: 382-392

LAGRANGE, E. (1957) Fécondité et régime chez *Planorbis glabratus*. -- Bull. Soc. Path. Exot. 50: 804-811

LEE, C. L. & LEWERT, R. M. (1956) The maintenance of *Schistosoma mansoni* in the laboratory. -- J. Infec. Dis. 99: 15-20

LO, C. T. (1967) The inhibiting action of ostracods on snail cultures. -- Trans. Amer. Micro. Soc. 86: 402-405

LO, C. T. (1972) Compatibility and host-parasite relationship between species of the genus *Bulinus* (Basommatophora: Planorbidae) and an Egyptian strain of *Schistosoma haematobium* (Trematoda: Digenea). -- Malacologia 11: 225-280

MacNAE, W. (1956) Aspects of life on muddy shores in South Africa. -- S. Afr. J. Sci. 53: 40-43

MALEK, E. A. (1950) Susceptibility of the snail *Biomphalaria boissyi* to infection with certain strains of *Schistosoma mansoni*. -- Amer. J. Trop. Med. 30: 887-894

---- (1958) Factors conditioning the habitat of bilharziasis intermediate hosts of the family Planorbidae. -- Bull. Wld. Hlth. Org. 18: 785-818

McCLELLAND, W.F.J. (1964) A method of breeding *Bulinus (Physopsis) nasutus* in the laboratory. -- Ann. Trop. Med. Parasit. 58: 265-269

MECHAM, J. A. & HOLLIMAN, R. B. (1972) An improved feeding procedure for *Biomphalaria glabrata*. -- J. Parasit. 58: 835

MICHELSON, E. H. (1957) Studies on the biological control of schistosome-bearing snails. Predators and parasites of fresh-water Mollusca: a review of the literature. -- Parasitology 47: 413-426

---- (1961) The effects of temperature on growth and reproduction of *Australorbis glabratus* in the laboratory. -- Amer. J. Hyg. 73: 66-74

MOORE, D. V., THILLET, C.J., CARNEY, D.M. & MELENEY, H.E. (1953) Experimental infection of *Bulinus truncatus* with *Schistosoma haematobium*. -- J. Parasit. 39: 215-221

MUIRHEAD-THOMSON, R.C. (1958) The ecology of vector snail habitats and mosquito breeding-places. The experimental approach to basic problems. -- Bull. Wld. Hlth. Org. 19: 637-659

NAJARIAN, H. H. (1960a) Maintenance and rearing of the snail *Bulinus truncatus* in the laboratory. -- J. Parasit. 46: 153

---- (1960b) The relation of water volume to egg production in the snail *Bulinus truncatus*. -- Texas Rep. Biol. Med. 18: 470-472

NOLAND, L. E. & CARRIKER, M. R. (1946) Observations on the biology of the snail *Lymnaea stagnalis appressa* during twenty generations in laboratory culture. -- Amer. Midl. Naturalist 36: 467-493

OLIVIER, L. & HASKINS, W. T. (1960) The effect of low concentrations of sodium pentachlorophenate on the fecundity and egg viability of *Australorbis glabratus*. -- Amer. J. Trop. Med. Hyg. 9: 199-205

OLIVIER, L., HASKINS, W. T. & GURIAN, J. (1962) The action of very low concentrations of sodium pentachlorophenate on freshly laid eggs of *Australorbis glabratus*. -- Bull. Wld. Hlth. Org. 27: 87-94

PAN, C. (1958) The general histology and topographic micro-anatomy of *Australorbis glabratus*. -- Bull. Harvard Mus. Comp. Zool. 119: 237-299

PAN, C. (1963) Generalized and focal tissue responses in the snail, *Australorbis glabratus*, infected with *Schistosoma mansoni*. -- Ann. N.Y. Acad. Sci. 113: 475-485

PAN, C. (1965) Studies on the host-parasite relationship between *Schistosoma mansoni* and the snail *Australorbis glabratus*. -- Amer. J. Trop. Med. Hyg. 14: 931-976

PELLEGRINO, J. & GONÇALVES, M. da H. G. R. (1965) A simple method for collecting egg

clutches of *Biomphalaria glabrata (Australorbis glabratus)* and for rearing newly hatched snails. -- J. Parasit. 51: 1014

PEREIRA, O.A. & DESLANDES, N. (1954) Resultados de uma tentiva para determinar a idade do *Australorbis glabratus* (Say, 1818). -- Rev. Serviço Especial de Saúde Pública, Rio de Janeiro 6: 433-465 (Not seen; vide Chernin, E. & Michelson, E.H., 1957a).

PERLOWAGORA-SZUMLEWICZ, A. (1958) Studies on the biology of *Australorbis glabratus*, schistosome bearing Brazilian snail. -- Rev. Bras. Mal. Rio de Janeiro 10: 459-529 (Not seen; vide Ritchie *et al.*, 1963a).

PIMENTEL, D. & WHITE, P.C., Jr. (1959a) Physiochemical environment of *Australorbis glabratus*, the snail intermediate host of *Schistosoma mansoni* in Puerto Rico. -- Ecology 40: 533-541

---- & ---- (1959b) Biological environment and habits of *Australorbis glabratus*. -- Ecology 40: 541-550

PRINGLE, G. (1960) Invasion of the egg masses of the mollusc *Bulinus (Physopsis) globosus*, by larval chironomids. -- Parasitology 50: 497-499

RIPSOM, C. A. (1949) Reduction of the time factor in rearing *Australorbis glabratus*. -- Amer. Midl. Naturalist 42: 757-758

RITCHIE, L.S., BERRIOS-DURAN, L.A. & DeWEESE, R. (1963a) Biological potentials of *Australorbis glabratus*: growth and maturation. -- Amer. J. Trop. Med. Hyg. 12: 264-268

RITCHIE, L.S., TAUBR, J. H. & EDWARDS, T.W. (1963b) Survival of laboratory-reared *Australorbis glabratus* infected with *Schistosoma mansoni*. -- J. Parasit. 49: 699-700

RITCHIE, L.S., HERNANDEZ, A. & ROSA-AMADOR, R. (1966) Biological potentials of *Australorbis glabratus*: life span and reproduction. -- Amer. J. Trop. Med. Hyg. 15: 614-617

ROWAN, W.B. (1958) Mass cultivation of *Australorbis glabratus*, intermediate host of *Schistosoma mansoni* in Puerto Rico. -- J. Parasit. 44: 247

SCHUTTE, C.H.J. & FRANK, G.H. (1964) Observations on the distribution of freshwater Mollusca and chemistry of the natural waters in the south-eastern Transvaal and adjacent northern Swaziland. -- Bull. Wld. Hlth. Org. 30: 389-400

SCOTT, J.A. (1942) The epidemiology of schistosomiasis in Venezuela. -- Amer. J. Hyg. 35: 337-366

SEMPER, C. (1874) Ueber die Wachsthums-bedingungen des *Lymnaeus stagnalis*. -- Arb. Zool. Inst. Würzburg, Bd. I: 137-167 (Not seen; vide Frank, G.H., 1963).

SENNA, I.A. & VIEIRA, E.C. (1970) Culture of the snail *Biomphalaria glabrata* on a simplified medium. -- Amer. J. Trop. Med. Hyg. 19: 568-570

SHAH, S.N. & GADGIL, R.K. (1955) Human schistosomiasis in India. Part I. The study of snails. -- Indian J. Med. Res. 43: 689-694

SHIFF, C.J. (1964A) Studies on *Bulinus (Physopsis) globosus* in Rhodesia. I. The influence of temperature on the intrinsic rate of natural increase. -- Ann. Trop. Med. Parasit. 58: 94-105

---- (1964b) Studies on *Bulinus (Physopsis) globosus* in Rhodesia. II. Factors influencing the relationship between age and growth. -- Ann. Trop. Med. Parasit. 58: 106-115

---- (1964c) Studies on *Bulinus (Physopsis) globosus* in Rhodesia. III. Bionomics of a natural population existing in a temporary habitat. -- Ann. Trop. Med. Parasit. 58: 240-255

---- (1966) The influence of temperature on the vertical movement of *Bulinus (Physopsis) globosus* in the laboratory and in the field. -- S. Afr. J. Sci. 62: 210-214

---- & GARNETT, B. (1967) The influence of temperature on the intrinsic rate of natural increase of the freshwater snail *Biomphalaria pfeifferi* (Krauss) (Pulmonata: Planorbidae). -- Archiv Hydrobiol. 62: 429-438

SIOLI, H. (1953) Schistosomiasis and limnology in the Amazon region. -- Amer. J. Trop. Med. Hyg. 2: 700-707

SODEMAN, W. A., Jr. (1970) Laboratory maintenance of *Biomphalaria pfeifferi*. -- J. Parasit. 56 (Sec. 2): No. 596

SOHN, I. G. & KORNICKER, L.S. (1972) Predation of schistosomiasis vector snails by Ostracoda (Crustacea). -- Science 175: 1258-1259

STANDEN, O. D. (1949) Experimental schistosomiasis. I. The culture of the snail vectors *Planorbis boissyi* and *Bulinus truncatus*. -- Ann. Trop. Med. Parasit. 43: 13-22

---- (1951) Some observations upon the maintenance of *Australorbis glabratus* in the laboratory. -- Ann. Trop. Med. Parasit. 45: 80-83

STIGLINGH, I. & van EEDEN, J.A. (1970) Notes on the feeding behaviour of *Bulinus (Bulinus)*

tropicus (Krauss) Basommatophora: Planorbidae. -- Wetenskaplike Bydraes van die P.U. vir C.H.O. Reeks B: Natuurwetenskappe, nr 22: 1-14

STIREWALT, M.A. (1954) Effect of snail maintenance on development of *Schistosoma mansoni*. -- Exp. Parasit. 3: 504-516

STURROCK, B. M. (1966) The influence of infection with *Schistosoma mansoni* on the growth rate and reproduction of *Biomphalaria pfeifferi*. -- Ann. Trop. Med. Parasit. 60: 187-197

---- (1967) The effect of infectionwith *Schistosoma haematobium* on the growth and reproduction rates of *Bulinus (Physopsis) nasutus productus*. -- Ann. Trop. Med. Parasit. 61: 321-325

---- & STURROCK, R.F. (1970) Laboratorystudies of the host-parasite relationship of *Schistosoma mansoni* and *Biomphalaria glabrata* from St.Lucia, West Indies. -- Ann. Trop. Med. Parasit. 64: 357-363

STURROCK, R.F. (1965) Studies on the biology of *Biomphalaria angulosa* Mandahl-Barth and on its ability to act as an intermediate host of *Schistosoma mansoni*. -- Ann. Trop. Med. Parasit. 59: 1-9

---- (1966) The influence of temperature on the biology of *Biomphalaria pfeifferi* (Krauss), an intermediate host of *Schistosoma mansoni*. -- Ann. Trop. Med. Parasit. 60: 100-105

---- & STURROCK, B. M. (1970) Observations on some factors affecting the growth rate and fecundity of *Biomphalaria glabrata* (Say). -- Ann. Trop. Med. Parasit. 64: 349-355

TAYLOR, E. L. & MOZLEY, A. (1948) A culture method for *Lymnaea truncatula*. -- Nature 161: 894

TURNER, F. M. (1927) On the effect of overcrowding on the growth of the water snails *Limnaea pereger* and *L. stagnalis*. -- Essex Nat. 22: 48 (Not seen; vide Wright, C.A., 1960)

van der SCHALIE, H. & BERRY, E. G. (1972) The effects of temperature on growth and reproduction of aquatic snails. -- (In Press) Water Quality Office, Environmental Protection Agency, Washington, D.C.

van der SCHALIE, H. & DAVIS, G. M. (1965) Growth and stunting in *Oncomelania* (Gastropoda: Hydrobiidae). -- Malacologia 3: 81-102

van SOMEREN, V. D. (1946) The habitats and tolerance ranges of *Lymnaea (Radix) caillaudi*, the intermediate snail host of liver fluke in East Africa. -- J. Anim. Ecol. 15: 170-197

VIEIRA, E.C. (1967a) Influence of vitamin E on reproduction of *Biomphalaria glabrata* under axenic conditions. -- Amer. J. Trop. Med. Hyg. 16: 792-796

VIEIRA, E.C. (1967b) Crescimento e reprodução de *Biomphalaria glabrata* em condições axênicas. -- Thesis of 'docência livre' Faculdade de Medicina, Universidade Federal de Minas Gerais, Belo Horizonte, Brazil. (Not seen, vide Senna, I.A. & Viera, E.C., 1970).

WARD, P. A., TRAVIS, D. & RUE, R. E. (1947) Methods of establishing and maintaining snails in the laboratory. -- U. S. Nat. Inst. Hlth. Bull. 189: 70-80

WATSON, J.M. (1950) Studies on bilharziasis in Iraq. Part V. Habitat of the vector snail, *Bulinus truncatus*, and its distribution in relation to the irrigation system. -- J. Fac. Med. Baghdad 14: 148-182. (Not seen; vide Malek, E.A., 1958).

WATSON, J.M. (1958) Ecology and distribution of *Bulinus truncatus* in the Middle East. With comments on the effect of some human activities in their relationship to the snail host on the incidence of bilharziasis haematobia in the Middle East and Africa. -- Bull. Wld. Hlth. Org. 18: 833-894

WATSON, J.M. & AL-ALI, A.S. (1961) The breeding of *Bulinus truncatus* in total darkness. -- J. Helminth., R.T. Leiper Supplement 199-204

WEBBE, G. (1962a) Population studies of intermediate hosts in relation to transmission of bilharziasis in East Africa. -- Bilharziasis, Ciba Foundation Symposium, ed. G.E.W. Wolstenholme and M. O'Connor. Little, Brown and Company, Boston: 7-22

---- (1962b) The transmission of *Schistosoma haematobium* in an area of Lake Province, Tanganyika. -- Bull. Wld. Hlth. Org. 27: 59-85

---- (1965) Transmission of bilharziasis. 1. Some essential aspects of snail population dynamics and their study. -- Bull. Wld. Hlth. Org. 33: 147-153

WILLIAMS, N.V. (1970a) Studies on aquatic pulmonate snails in Central Africa. I. Field distribution in relation to water chemistry. -- Malacologia 10: 153-164

---- (1970b) Studies on aquatic pulmonate snails in Central Africa. II. Experimental investigation of field distribution patterns. -- Malacologia 10: 165-180

WINSOR, C.P. & WINSOR, A.A. (1935) Longebity and fertility in the pond snail, *Lymnaea columella*. -- J. Washington Acad. Sci. 25: 302-307

WORLD HEALTH ORGANIZATION (1957) Study group on the ecology of intermediate snail hosts of bilharziasis. -- Wld. Hlth. Org. Tech. Rept. Ser. 120: 1-38

WRIGHT, C. A. (1956) Some factors affecting the susceptibility of snails to infection with miracidia of *Schistosoma* spp. -- Bull. Soc. Path. Exot. 49: 1211-1220

---- (1960) The crowding phenomenon in laboratory colonies of freshwater snails.--Ann. Trop. Med. Parasit. 54: 224-232

---- & BENNETT, M.S. (1967) Studies on *Schistosoma haematobium* in the laboratory. I. A strain from Durban, Natal, South Africa. -- Trans. Roy. Soc. Trop. Med. Hyg. 61: 221-227

XAVIER, M. de L. S., FRAGA DE AZEVEDO, J. & AVELINO, I. (1968) Importance d'*Oscillatoria formosa* Bory dans la culture au laboratoire des mollusques vecteurs du *Schistosoma haematobium*. -- Bull. Soc. Path. Exot. 61: 52-66

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

FURTHER NOTES ON PSEUDOGASTROPODS

Recently La Rocque (1973) discussed pseudogastropods: organisms that have been misidentified as gastropods and gastropods that have been incorrectly assigned to various phyla. His examples call attention to actual problems faced by those who deal with nomenclature. It seems desirable to record briefly two extreme cases: a fish that masqueraded as a gastropod (Hanna, 1925) and a group of gastropods that moved several giant steps downward in the Linnaean hierarchy and were interpreted as protozoans (Browne, 1971).

JAMES X. CORGAN
Geology Department
Austin Peay State University
Clarksville, Tennessee 37040

REFERENCES

BROWNE, R. G. (1971) Misassignment of Silurian gastropod protoconch casts to taxa of Foraminifera. -- Jour. Paleont. 45(1): 141

HANNA, G. D. (1925) *Zalophancylus*, a fish vertebra, not a mollusk. -- Nautilus 39 (1): 18-19

La ROCQUE, A. (1973) Pseudogastropods. -- Sterkiana 51: 10

BOOKS RECEIVED

SHOUP, Charles S. (1974) A Bibliography of the Zoology of Tennessee and the Tennessee Valley Region. -- U. S. Atomic Energy Commission. Office of Information Services. Technical Information Center. iv, 251 p.

As its title indicates, this scholarly work lists published papers on the animals of the Tennessee Valley region from Protozoa to Mammalia, preceded by a section of 278 items on Ecology, General Zoology and Management. The items are numbered and arranged alphabetically by authors under each section. The Mollusca are well represented (Nos. 460-787) and present a useful introduction to the literature of this interesting part of the country. In addition, malacologists interested in the relationships of Mollusca to other groups of invertebrates will find much useful data under practically every one of the sections. After leafing through this work, one cannot help wishing that we had comparable compilations for every part of the country or, better still, for every part of the world.

A. L.

RESOURCES FOR MALACOLOGICAL RESEARCH IN ORTON MEMORIAL LIBRARY OF GEOLOGY

REGINA BROWN

Librarian, Orton Memorial Library of Geology
Ohio State University, Columbus, Ohio 43210

Orton Hall, on the campus of the Ohio State University, Columbus, is a dramatic, appropriate setting for a geological library. The Richardsonian Romanesque structure is constructed of forty varieties of Ohio building stone, arranged in stratigraphic order. Red sandstone around the windows, doors, and chimes tower and Berea Sandstone on the first and second floors represent the Mississippian age. The basement is constructed of Springfield Dolomite and Dayton Limestone (Silurian) and Columbus Limestone (Devonian) forms the steps leading to the main entrance. Red sandstone heads of extinct animals encircle the top of the chimes tower. The grounds surrounding the building are enhanced with various concretions and a thirty-ton erratic boulder of anorthosite of Pleistocene origin.

Edward Orton, professor of geology and the first president of the University, conceived the idea for the unique building. As a fitting memorial to his father, Edward Orton, Jr. established and furnished a library of geological literature off the main foyer, adjacent to the Orton Geological Museum. Paintings of Ohio state geologists and geological landscapes complement the warm oak paneling and cork tile floors in the main reading room.

Since its formal dedication in 1920, Orton Library's collection has grown to 42,500 books, 477 periodical titles, and 43,700 maps. Many of its first editions are from the Ortons' personal libraries. The Library is a depository for all Ohio Geological Survey publications, not only those published by the Survey, but also those publications sent to that organization on a gift or exchange basis by other state geological surveys, surveys of foreign countries, and numerous geological organizations.

Although the Library's holdings encompass the entire range of geological research, from the traditional fields of mineralogy and paleontology to lunar geology and environmental pollution, one of its strengths is molluscan literature. It is this segment of the collection we wish to discuss. A guide to information sources (bibliographies and other reference tools) prefaces a list of serial publications that publish molluscan research. Finally, we mention the general treatises and regional studies in the Orton Memorial Library collection.

GUIDE TO INFORMATION SOURCES

There are both primary and secondary sources of information in a geological library. To obtain primary source literature (*e.g.*, books, reports, serial articles), the researcher frequently consults general bibliographies, current and retrospective:

NICKLES, John M. (1923-1924) Geologic literature of North America, 1785-1918. (U.S.G.S. Bulletin 746 and 747) Washington, D.C., Govt. Prtg. Office, 2 vols.

U.S. GEOLOGICAL SURVEY (1923-1970) Bibliography of North American geology. Washington, Govt. Prtg. Office.

Annual; issued as U.S.G.S. Bulletins, covers the period 1919-1970. Cites publications 'concerning the geology of the North American continent, Greenland, the West Indies and adjacent islands, Hawaii, Guam, and other island possessions but not the trust territories. Articles by American authors published in foreign journals are cited if they deal with North American localities or are of a general

nature ... Articles on North America by foreign authors are included regardless of place of publication.' Arranged alphabetically by author with a subject index. Complements the Bibliography and index of geology exclusive of North America *until the latter changed its name to* Bibliography and index of geology *in 1969 and began world-wide coverage. Ceased publication with 1970 volume. See* Bibliography and index of geology *after that date.*

GEOLOGICAL SOCIETY OF AMERICA (1934-) Bibliography and index of geology. Boulder, Colo.

Monthly; world-wide in scope. Each issue is divided into 21 intradisciplinary categories and the citations within each category are arranged alphabetically by authors. Descriptors or key words accompany many of the citations. The code at the end of each citation represents a unique accession number in the American Geological Institute's GEO-REF, a computerized, indexed reference file. There is also a subject index for each monthly issue and annual compilation.

ZOOLOGICAL RECORD (1864-) London, Zoological Society of London.

Annual; contains roughly 15,000 references a year from world-wide literature. Issued in sections (e.g., Mollusca), each with a subject index.

SPECIALIZED BIBLIOGRAPHIES ARE ANOTHER SOURCE OF LITERATURE:

BOYLE, Cornelius Breckinridge (1893) A catalogue and bibliography of North American Mesozoic Invertebrata. (U.S.G.S. Bulletin 102, Washington, Govt. Prtg. Office, 315 p.

BRANSON, CARL COLTON (1948) Bibliographic Index of Permian Invertebrates. (Geological Society of America. Memoir 26) New York, 1049 p.

HAAS, Otto (1958) Recent literature on Mesozoic ammonites. (Jour. Paleont. 32 (3):624-635).

KEEN, Angeline Myra (1937) An abridged checklist and bibliography of West North American marine Mollusca. Stanford, Calif., Stanford Univ. Press; London, H. Milford, Oxford University Press. 87 p.

MARCOU, John Belknap (1885) Bibliography of publications relating to the collection of fossil invertebrates in the United States National Museum, including complete lists of the writings of Fielding B. Meek, Charles A. White and Charles D. Walcott. (Bibliographies of American naturalists, 3; U.S. National Museum Bull. 30) Washington, D.C. 333 p.

RICHARDS, Horace Gardiner, comp. (1968) Catalogue of invertebrate fossil types at the Academy of Natural Sciences of Philadelphia. (Academy of Nat. Sci. Phila., Spec. Publ. no. 8) Philadelphia, Acad. Nat. Sci. 222p.

VOKES, Harold E. (1967) Genera of the Bivalvia—a systematic and bibliographic catalogue. (Bull. Amer. Paleontology, v. 51, no. 232, p. 111-394)

WELLER, Stuart (1898) A bibliographic index of North American Carboniferous invertebrates. (U.S.G.S. Bull. 153) 653 p.

WHITE, Charles Abiathar (1878) Bibliography of North American invertebrate Paleontology, being a report upon the publications that have hitherto been made upon the invertebrate paleontology of North America, including the West Indies and Greenland. By C. A. White and H. Alleyne Nicholson. (U.S.G.S. of the Territories. Misc. Publ. no. 10) 132 p.

YOCHELSON, Ellis L. (1967) A bibliographic index of North American Late Paleozoic Hyolitha, Amphineura, Scaphopoda, and Gastropoda, by E. L. Yochelson and Burnett W. Saunders. (U.S.G.S. Bull. 1210) 271 p.

IN ADDITION TO BIBLIOGRAPHIC SERIALS AND COMPILATIONS, ONE MUST BE ACQUAINTED WITH OTHER REFERENCE SOURCES IN THE LIBRARY:

ATLASES

HALLAM, A., ed. (1973) Atlas of palaeobiogeography. Amsterdam, New York, Elsevier, 531 p.

JOLEAUD, Léonce (1939) Atlas de paléobiogéographie. Paris, Lechevalier, 40 p.

VERNIORY, René (1970) Atlas de paléontologie des invertébrés. Genève, Georg. 223 p.

BIOGRAPHICAL DIRECTORIES

AMERICAN MALACOLOGISTS, 1973-74 (1973) Editor-in-chief: R. Tucker Abbott. Falls Church, Va. 494 p.

AMERICAN MEN AND WOMEN OF SCIENCE (1971) 12th ed., New York, Bowker, 6 vols.

LAMBRECHT, K. (1938) Palaeontologi. Catalogus bio-bibliographicus, by K. Lambrecht, W. and A. Quenstedt, (Fossilium Catalogus I: Animalia, pars 72, 495 p.)

WESTERMANN, G.E.G., comp. (1968) Directory of palaeontologists of the world (excluding Soviet Union and continental China) 2d ed. Sponsored by the International Palaeontological Union. Hamilton, Ontario, Canada, McMaster University. 250 p.

CATALOGS AND COLLECTIONS

ANDERSON, Ernest Masson (1936) Catalogue of types and figured specimens of fossils in the Geological Survey collections now exhibited in the Royal Scottish Museum, Edinburgh. London, H.M. Stat. Off. 77p.

BRITISH MUSEUM (Natural History) Department of Geology (1886) A guide to the exhibition galleries of the Department of Geology and Palaeontology in the British Museum (Natural History) 4th ed. London, Printed by order of the Trustees. 117 p.

---- (1888-1951) Catalogue of the fossil Cephalopoda in the British Museum (Natural History) by Arthur H Foord. London, Printed by order of the Trustees. 5 vols.

---- (1891) Systematic list of the Frederick E. Edwards collection of British Oligocene and Eocene Mollusca in the British Museum (Natural

History), with references to the type-specimens from similar horizons contained in other collections belonging to the Geological Department of the Museum. By Richard Bullen Newton. London, Printed by order of the Trustees. 365 p.

---- (1907) A guide to the fossil invertebrate animals in the Department of Geology and Palaeontology in the British Museum (Natural History). London, Printed by order of the Trustees. 182 p.

---- (1923) A guide to the exhibition galleries of the Department of Geology and Palaeontology. London, Printed by order of the Trustees. 64 p.

---- (1938) A catalogue of the ammonites of the Liassic family Liparoceratidae in the British Museum (Natural History) by L. F. Spath. London, Printed by order of the Trustees. 191 p.

BRITISH MUSEUM (Natural History) Department of Zoology (1913) Catalogue of the British species of *Pisidium* (Recent and fossil) in the collections of the British Museum (Natural History). London, Printed by order of the Trustees. 144 p.

CANADA, GEOLOGICAL SURVEY (1960-) Catalogue of type invertebrate fossils of the Geological Survey of Canada, by Thomas E. Bolton, Ottawa, Queen's Printer.

DOUVILLÉ, Robert (1915) Études sur les Cosmocératidés des collections de l'École nationale supérieure des Mines et de quelques autres collections publiques ou privées. (France. Service de la carte géologique de la France. Mémoires pour servir à l'explication de la carte géologique détaillée de la France) Paris, Imprimerie Nationale. 75 p.

HANZAWA, Shōshirō, comp. (1961) Catalogue of type-specimens of fossils in Japan. Compiled by Shōshirō Hanzawa, Kiyoshi Asano, and Fuyuji Takai. Tokyo, Palaeontological Society of Japan. 422 p.

KEEN, Angeline Myra (1939) Illustrated key to West North American pelecypod genera, by A. Myra Keen and Don L. Frizzell. Stanford, Calif., Stanford University Press; London, H. Milford, Oxford University Press. 28 p.

MANTELL, Gideon Algernon (1851) Petrifactions and their teachings: or, A hand-book to the Gallery of Organic Remains of the British Museum. London, H. G. Bohn. 496 p.

MILLER, Samuel Almond (1877) The American Palaeozoic fossils: a catalogue of the genera and species, with names of authors, dates, places of publication, groups of rocks in which found, and the etymology and signification of the words, and an introduction devoted to the stratigraphical geology of the Palaeozoic rocks. Cincinnati, Ohio, The Author, 253 p.

STENZEL, Henryk Bronislaw (no date) Type Invertebrate fossils of North America (Eocene, Paleocene, Oligocene). Prepared by H.B. Stenzel and F. E. Turner. Austin, Texas, Bureau of Economic Geology. Cards 1-148.

TURNER, Ruth Dixon (1966) A survey and illustrated catalogue of the Teredinidae (Mollusca: Bivalvia). Cambridge, Mass., Museum of Comparative Zoology, Harvard University. 265 p.

TYPE INVERTEBRATE FOSSILS OF NORTH AMERICA (DEVONIAN) (1936-1938) Philadelphia, Wagner Free Institute of Science. 3 vols.

WARD, Henry Augustus (1866) Catalogue of casts of fossils, from the principal museums of Europe and America, with short descriptions and illustrations. Rochester, New York, Benton and Andrews, 228 p.

WILLARD, Bradford (1966) The Harvey Bassler collection of Peruvian fossils. Bethlehem, Pa., Lehigh University. 255 p.

WOOD, WILLIAM (1856) Index Testaceologicus, an illustrated catalogue of British and foreign shells, containing about 2800 figures accurately coloured after nature. A new and entirely revised edition, with ancient and modern appellations, synonyms, localities, etc., by Sylvanus Hanley. London, Willis and Sotheran. 234 p.

WOODWARD, Arthur Smith (1908) Illustrations of type specimens of Inferior Oolite ammonites in the Sowerby collection. London, printed for the Palaeontographical Society. 33 p.

Catalogs are also published in periodicals, as the following examples:

CHAPPARS, Michael Stephen (1936) Catalog of the type specimens of fossils in the University of Cincinnati Museum. (Ohio Jour Sci., v. 36, no. 1, p. 1-45).

FLEMING, C. A. (1966) Marwick's illustrations of New Zealand shells, with a checklist of New Zealand Cenozoic Mollusca. (New Zealand. Department of Science and Industrial Research. Bull. 173, 456 p.

GRANT, Ulysses Simpson, IV (1931) Catalogue of the marine Pliocene and Pleistocene Mollusca of California and adjacent regions, by U.S. Grant and Hoyt Rodney Gale. (San Diego Society of Natural History. Memoir, v. 1, 1036 p.)

PURNELL, Louis R. (1968) Catalog of the type specimens of invertebrate fossils. Part I: Palaeozoic Cephalopoda. (U.S. National Museum. Bull. 262) Wash., D. C., Govt. Prtg Off. 198 p.

FOSSIL INDEXES

Fossilium Catalogus. I. Animalia. (1913-) 's-Gravenhage, W. Junk. Pars 1-

A comprehensive series; each part is on a separate subject, authored by a specialist.

GRABAU, Amadeus William (1909-1910) North American Index Fossils, Invertebrates, by Amadeus W. Grabau and Hervey Woodburn Shimer. New York, A. G. Seiler. 2 vols.

JOINT COMMITTEE ON INVERTEBRATE PALEONTOLOGY (1953-) Treatise on invertebrate paleontology. Edited by Raymond C. Moore. Boulder, Colo., Geological Society of America and Lawrence, Kansas, University of Kansas Press. In Progress.

A series on the major groups of invertebrate animals. Parts are divided according to phylum, and the orders, classes, and genera in each phylum are described, with references to the literature. Of interest to malacologists:

Part I - Mollusca 1 (Mollusca general features, Scaphopoda, Amphineura, Monoplacophora, Gastropoda general features, Archaeogastropoda, mainly Paleozoic Caenogastropoda and Opisthobranchia) 1960. 351 p., 1732 figs.

Part J - Mollusca 2 (Gastropoda, Streptoneura exclusive of Archaeogastropoda, Euthyneura) In preparation.

Part K - Mollusca 3 (Cephalopoda general features, Endoceratoidea, Actinoceratoidea, Nautiloidea, Bactritoidea) 1964. 519 p., 2382 figs.

Part L - Mollusca 4 (Ammonoidea) 1957. 490 p., 3800 figs. Revision in preparation.

Part M - Mollusca 5 (Coleoidea) In preparation.

Part N - Mollusca 6 (Bivalvia) 3 vols. v. 1 and 2: 1969, 952 p., 6198 figs.; v 3: 1971, 272 p., 742 figs.

SHIMER, Hervey Woodburn (1944) Index fossils of North America; a new work based on the complete revision and reillustration of Grabau and Shimer's North American Index Fossils. (Technology Press, Mass. Inst. of Technology) New York, Wiley; London, Chapman and Hall. 837 p.

HANDBOOKS AND MANUALS

BEERBOWER, James Richard (1971) Field guide to fossils. (Earth Science Curriculum Project. ESCP pamphlet series, PS-4) Boston, Houghton Mifflin. 54 p.

CAMP, Charles Lewis (1937) Methods in paleontology, by Charles L. Camp and G. Dallas Hanna. Berkeley, Univ. of California Press, 153 p.

CHENU, Jean Charles (1859-1862) Manuel de conchyliologie et de paléontologie conchyliologique. Paris, V. Masson. 2 vols.

FISCHER, Paul Henri (1887) Manuel de conchyliologie et de paléontologie conchyliologique; ou, Histoire naturelle des mollusques vivants et fossiles. Paris, F. Savy. 1391 p.

HÖLDER, Helmut (1964) Jura. (Handbuch der stratigraphischen Geologie, Bd. 4) Stuttgart, F. Enke. 603 p.

KIRKALDY, John F. (1967) Fossils in colour. London, Blandford Press. 223 p.

KUMMEL, Bernhard (1965) Handbook of paleontological techniques. Prepared under the auspices of the Paleontological Society. Edited by B. Kummel and David Raup. San Francisco, W. H. Freeman. 852 p.

MIDDLEMISS, Frank Alexander (1968) A guide to invertebrate fossils. (Hutchinson biological monographs) London, Hutchinson, 128 p.

NEAVERSON, Ernest (1928) Stratigraphical palaeontology; a manual for students and field geologists. London, Macmillan. 525 p. (2d ed., revised and enlarged, published by Clarendon Press, Oxford, Eng., 1955, 806 p.)

ORLOV, Yu. A., ed. (1962-) Fundamentals of paleontology. Osnovy Paleontologii. A manual for paleontologists and geologists of the USSR. Translated by the Israel Program for Scientific Translations staff. Jerusalem, published for the National Science Foundation by IPST.

PHILIPPI, Rudolph Amandus (1853) Handbuch der Conchyliologie und Malacozoologie. Halle, E. Anton. 548 p.

PRATT, Henry Sherring (1935) A manual of the common invertebrate animals, exclusive of insects. Revised ed. New York, Macmillan. 854 p.

TRYON, George Washington (1885-1935) Manual of Conchology; structural and systematic, with illustrations of the species. Second series: Pulmonata. Philadelphia. Published by the Conchological Department, Academy of Natural Sciences of Philadelphia. 28 vols.

WEBB, Walter Freeman (1935) A handbook for shell collectors; illustrations and descriptions of 1100 species of Mollusca. Rochester, N.Y., St. Petersburg, Fla., The Author? 146 p.

WOODWARD, Samuel Pickworth (1851-1856) A manual of the Mollusca; or, Rudimentary treatise of Recent and fossil shells. London, J. Weale. 510 p. (Reprint of 4th ed. (1880) publ. by C. Lockwood, London, 1890, 628 p.)

ZITTEL, Karl Alfred *Ritter von* (1880-1893) Handbuch der Palaeontologie. München und Leipzig, R. Oldenbourg. 2 vols. in 5.

NOMENCLATORS

BULLETIN OF ZOOLOGICAL NOMENCLATURE (1943-) London, Printed by order of the International Commission on Zoological Nomenclature and sold by the International Trust for Zoological Nomenclature.

INTERNATIONAL COMMISSION ON ZOOLOGICAL NOMENCLATURE (1961) Code international de nomenclature zoologique, adopté par le XVe Congrès International de Zoologie. Editorial Committee: N. R. Stoll, chairman, and others. London, Published for the International Commission on Zoological Nomenclature by the International Trust for Zoological Nomenclature. 176 p.

NEAVE, Sheffield Airey, ed. (1939-1940) Nomenclator zoologicus; a list of the names of genera and subgenera in zoology from the tenth edition of Linnaeus, 1758, to the end of 1935. Zoological Society of London. 4 vols.

SERIAL PUBLICATIONS

Serial publications are an excellent source of information covering retrospective and current studies in molluscan research. We have previously mentioned bibliographic serials under 'Guide to Information Sources.' In addi-

tion, there are serials of a general or specialized nature in the Orton Library collection. They are issued by governmental agencies (such as geological surveys), associations and scientific societies, universities and other learned institutions, museums, book publishers and private sources as numbered series, monographs, proceedings, and field trip guidebooks. In the following selected list of serials, those titles frequently containing research of interest to malacologists are designated with an asterisk.

GOVERNMENTAL AGENCIES
UNITED STATES
U.S. Geological Survey, Washington, D. C. *(See also publications issued prior to 1879 under its former name 'U. S. Geological and Geographical Survey of the Territories.')*
* Annual Report
* Bulletin
* Journal of Research of the U.S. Geological Survey
* Monograph
* Professional Paper

State geological surveys regularly publish results of regional research in their annual reports, bulletins, circulars, reports of investigations, etc. The publications are indexed, as are those of the U.S.G.S., in the U.S.G.S.'s Bibliography of North American Geology *(discontinued after 1970) and the Geological Society of America's* Bibliography and Index of Geology *(a monthly publication, worldwide in scope). The surveys will supply a list of their publications upon request.*

FOREIGN
Geological surveys or other governmental agencies outside the U.S. issue their publications at irregular intervals. The one notable exception is the Geological Survey of Canada. One may find these publications cited in the aforementioned *Bibliography and index to Geology*.
Attention will be called to the most significant papers published by these agencies in a future publication now in preparation.

ASSOCIATIONS AND SCIENTIFIC SOCIETIES
UNITED STATES
Academy of Natural Sciences of Philadelphia
* Notulae Naturae
* Proceedings
* Monographs
Special Publications
Academy of Sciences of St. Louis
* Transactions
American Association for the Advancement of Science, Washington, D.C.
Proceedings
Science
American Association of Museums, New York
The Museum News
American Association of Petroleum Geologists, Tulsa
Bulletin
American Geographical Society, New York
The Geographical Review
American Geological Institute, Washington, D.C.
* Akademiia Nauk SSR. Doklady: Earth Sciences sections. (English trans.)
* International Geology Review
* Paleontological Journal (Translation of the Russian Paleontologicheskiy Zhurnal)
American Malacological Union, Havertown, Pa.
* The Nautilus
American Philosophical Society, Phila.
Proceedings
Transactions
Association of Geology Teachers, Fort Collins, Colo.
Journal of Geological Education.
Boston Society of Natural History
* Proceedings
Buffalo Society of Natural Sciences
Bulletin
California Academy of Sciences, San Francisco
Proceedings
Cincinnati Society of Natural History
Journal
Connecticut Academy of Arts and Sciences, New Haven
Transactions
Des Moines Academy of Science
Bulletin
Florida Academy of Sciences, Gainesville
Quarterly Journal
Geological Society of America, Boulder, Colo.
* Bulletin
* Memoir
Proceedings (Ceased publication after 1968)
* Special Paper
Gulf Coast Association of Geological Societies, Houston
Transactions
Indiana Academy of Science, Indianapolis
Proceedings
Iowa Academy of Sciences, Des Moines
Proceedings
Michigan Academy of Science, Arts and Letters
Papers
Paleontological Society, Berkeley, Calif.
* Journal of Paleontology
San Diego Society of Natural History
* Memoirs
* Transactions
Sigma Gamma Epsilon, Norman, Okla.
The Compass

Smithsonian Institution, Washington, D.C.
* Annual Report
* Atoll Research Bulletin
* Miscellaneous Collections
* Smithsonian Contributions to Zoology
* Smithsonian Contributions to Paleobiology
Society of Economic Paleontologists and Mineralogists, Tulsa, Okla.
* Journal of Paleontology
Washington Academy of Sciences, Washington, D.C.
Journal
West Virginia Academy of Science, Morgantown, W. Va.
Proceedings

MIDDLE AMERICA
MEXICO
Sociedad Geológica Mexicana, México, D.F.
Boletín
JAMAICA
Geological Society of Jamaica, Kingston
Journal (Geonotes)

SOUTH AMERICA
ARGENTINA
Asociación Geológica Argentina, Buenos Aires
Revista
Asociación Paleontológica Argentina, Buenos Aires
* Ameghiniana
PERU
Sociedad Geológica del Peru, Lima
Boletín

EUROPE
AUSTRIA
Geologische Gesellschaft in Wien
Mitteilungen
BELGIUM
Association pour l'Étude de la Paléontologie et de la Stratigraphie houillères, Bruxelles
* Publication
Société Belge de Géologie, de Paléontologie et d'Hydrologie, Bruxelles
* Bulletin
BULGARIA
Bulgarska Akademiia na Naukite, Sofia. Geologicheski Institut
Trudove vurkhu geologiiata na Bulgariia. Seriia paleontologiia
CZECHOSLOVAKIA
Slovenská Akadémia vied a Umení, Bratislava
Geologický sborník
DENMARK
Denmark. Kommissionen for Videnskabelige Undersøgelser i Grønland, Copenhagen
Meddelelser om Grønland
ENGLAND
British Antarctic Survey, London
Bulletin
East Midlands Geological Society, Nottingham
The Mercian Geologist
Falkland Islands Dependencies Survey, London
Scientific Reports
Geologists' Association, London
Proceedings
Geological Society of London
Journal
Transactions
Liverpool Geological Society
Geological Journal (Published jointly with Manchester Geological Association)
Mineralogical Society, London
The Mineralogical Magazine and Journal of the Mineralogical Society
Palaeontographical Society, London
* Publications
Palaeontological Association, London
* Palaeontology
* Special papers in Palaeontology
Ray Society, London
Publications
Royal Society of London
Philosophical Transactions. Series B: Biological Sciences
Yorkshire Geological Society, Leeds
Proceedings

FRANCE
Société Géologique de France, Paris
* Bulletin
Compte rendu sommaire des séances
* Mémoires, Paléontologie
Société Géologique du Nord, Lille
Annales
Société Nationale des Pétroles d'Aquitaine. Centre de Recherches de Pau
Bulletin

GERMANY
Deutsche Geologische Gesellschaft, Berlin
Zeitschrift
Deutsche Gesellschaft für Geologische Wissenschaften, Berlin
Paläontologische Abhandlungen. Abt. A: Paläozoologie
Deutsche Quartärvereinigung, Hannover
Eiszeitalter und Gegenwart (Published in Öhringen, Württ.
Geologische Vereinigung, Koblenz
Geologische Rundschau (Published in Stuttgart)
Naturforschende Gesellschaft zu Freiburg i. B.
Berichte

HUNGARY
Magyar Földtani Tarsulat Folyóirata, Budapest
Földtani közlöny

IRELAND
Geological Society of Dublin
Journal

ITALY
Accademia Nazionale dei Lincei, Rome. Classe di Scienze Fisiche, Matematiche e Naturali
Memorie (Fisica, chimica, geologia, paleontologia e mineralogia (Atti)

Società di Naturalisti in Napoli
Bolletino
Società Geologica Italiana, Rome
Bolletino
NETHERLANDS
Geologisch-Mynbouwkundig Genootschap voor Nederland en Koloniën, 's-Gravenhage
Verhandelingen .... Geologische serie
NORWAY
Norsk Geologisk Forening, Oslo.
Norsk Geologisk Tiddskrift
Norske Videnskaps-Akademi i Oslo. Matematisk-Naturvidenskapelig Klasse
Skrifter
POLAND
Polska Akademia Nauk, Warsaw
* Acta Palaeontologica Polonica
Polska Akademia Nauk, Oddział w Krakowie
Folia Quaternaria
SCOTLAND
Edinburgh Geological Society
Scottish Journal of Geology (Published jointly with the Geological Society of Glasgow)
Transactions
Geological Society of Glasgow
Transactions
Royal Scottish Geographical Society, Edinburgh
Scottish Geographical Magazine
SPAIN
Sociedad Española de Historia Natural, Madrid
Boletín. Seccion geológica
SWITZERLAND
Société Paléontologique Suisse, Basel
* Schweizerische palaeontologische Abhandlungen. Mémoires suisses de paléontologie
THE SOVIET UNION
RUSSIA
Akademiia Nauk SSSR, Moscow
* Doklady (American Geological Institute publishes an English translation of the 'Earth Sciences' sections)
Geokhimiia
Priroda
UKRAINE
Lvov Geological Society
Geologicheskiĭ sbornik
Paleontologicheskii sbornik

ASIA
CHINA
Geological Society of China, Peking
Bulletin
JAPAN
Japan Association for Quaternary Research, Tokyo
The Quaternary Research
National Research Council of Japan, Tokyo
Japanese Journal of Geology and Geography; Transactions and Abstracts
Palaeontological Society of Japan, Tokyo
* Special Papers
* Transactions and Proceedings. New Series

AFRICA
Geological Society of South Africa, Johannesburg
Transactions

AUSTRALIA AND OCEANIA
AUSTRALIA
Geological Society of Australia, Adelaide
Journal
Royal Society of Victoria, Melbourne
Proceedings
Royal Society of Western Australia, Perth
Journal
NEW ZEALAND
Royal Society of New Zealand, Wellington
Transactions and Proceedings

UNIVERSITIES AND OTHER INSTITUTIONS
NORTH AMERICA
CANADA (PROVINCES)
ONTARIO
McMaster University. Department of Geology, Hamilton
Publications
Royal Canadian Institute, Toronto
Transactions
UNITED STATES (INDIVIDUAL)
CALIFORNIA
California. University, Berkeley-Los Angeles
* Publications in Geological Sciences
Stanford University. Department of Geology, Stanford, Calif.
Contributions
COLORADO
Colorado. University, Boulder
University of Colorado Studies. Series in Earth Sciences
CONNECTICUT
Yale University, New Haven
* American Journal of Science
Journal of Marine Research (Sears Foundation for Marine Research, Bingham Oceanographic Laboratory
* Radiocarbon
DISTRICT OF COLUMBIA
Carnegie Institution of Washington, Washington, D.C.
Publications
FLORIDA
Miami. University. Marine Laboratory, Coral Gables.
Bulletin of Marine Science of the Gulf and Caribbean
INDIANA
Notre Dame. University, Notre Dame, Ind.
* The American Midland Naturalist

IOWA
Iowa. University, Iowa City
Studies in Natural History
KANSAS
Kansas. University, Topeka
* University of Kansas Paleontological Contributions
LOUISIANA
Tulane University, New Orleans
* Tulane Studies in Geology and Paleontology
MARYLAND
Johns Hopkins University, Baltimore
The Johns Hopkins University Studies in Geology
MISSOURI
Missouri. University, Columbia
The University of Missouri Studies
NEW YORK
Paleontological Research Institution, Ithaca
* Bulletins of American Paleontology
* Palaeontographica Americana
NORTH CAROLINA
Duke University. Department of Geology, Durham
Southeastern Geology
OHIO
Denison University, Granville
* Journal of the scientific laboratories of Denison University
The Ohio State University, Columbus
* The Ohio Journal of Science (Published jointly by O.S.U. and the Ohio Academy of Science)
PENNSYLVANIA
Wagner Free Institute of Science, Philadelphia
Bulletin
TEXAS
Texas. University, Austin
Bulletin
Publications
WASHINGTON
Washington (State) University, Seattle
Memoirs of the University of Washington
University of Washington Publications in Geology

MIDDLE AMERICA
MEXICO
Mexico (City) Universidad Nacional. Instituto de Geologia
Boletîn
Paleontología mexicana

SOUTH AMERICA
BRAZIL
Rio de Janeiro, Brazil (State). Universidade Federal
Instituto de Geociências
Geologia. Boletim
Rio Grande do Sul, Brazil (State). Universidade Federal
Escola de Geologia, Porto Alegre
Notas e estudos
Publicação especial
PERU
Peru. Instituto Geológico, Lima
Boletín

EUROPE
BELGIUM
Brussels. Institut Royal des Sciences Naturelles de Belgique
* Bulletin
FRANCE
Centre d'études et de documentation paléontologiques, Paris
Annales
Faculté des Sciences de Paris
Revue de micropaléontologie
Paris. Institut Français du Pétrole
Revue de l'Institut Français du Pétrole et Annales des combustibles liquides
Strasbourg. Université. Service de la Carte Géologique d'Alsace et de Lorraine
Mémoires
GERMANY
Hamburg. Geologisch-Paläontologisches Institut
Mitteilungen
Marburg. Universität. Geologisch-Paläontologisches Institut
Geologica et Palaeontologica
Münster. Universität. Geologisch-Paläontologisches Institut
Münstersche Forschungen zur Geologie und Paläontologie
HUNGARY
Hungary. Földtani Intézet, Budapest
* Geologica Hungarica. Series Palaeontologica
ITALY
Genoa. Universitá. Istituto di Geologia
Atti
Rome. Universitá. Istituto di Geologia e Paleontologia
Geologica Romana
NORWAY
Oslo. Universitetsforlaget
* Lethaia, an international journal of Paleontology and stratigraphy
Oslo. Norsk Polarinstitut
Årbok
Skrifter
POLAND
Warsaw. Instytut Geologiczny
Biuletyn. Bulletin
Kwartalnik geologiczny
ROMANIA
Romania. Institutul Geologic, Bucharest
Dări de seamă ale sedintelor
Memorii
SPAIN
Madrid. Instituto de Investigaciones Geológicas 'Lucas Mallada'
Estudios geológicos

SPAIN (CONT.)
Madrid. Universidad. Facultad de Ciencias
Col-pa; Coloquios de la Cátedra de Paleontología
SWEDEN
Lund. Universitet
Acta Universitatis Lundensis. Lunds Universitets Årsskrift
Stockholm. University
Stockholm Contributions in Geology
Upsala. Universitet
Bulletin of the Geological Institution
YUGOSLAVIA
Yugoslavia. Geoloskirudarški Institut, Zagreb
Geološki vjesnik
Zavod za Geološka i Geofizička Istraživanja, Beograd
Vesnik. Serija A: Geologija

THE SOVIET UNION
RUSSIA
Akademiia Nauk SSSR. Paleontologicheskiĭ Institut, Moscow
* Trudy
Leningrad. Gornyĭ Institut
Zapiski
Leningrad. Nauchno-Issledovatel'skiĭ Institut Geologii Arktiki
Trudy
Leningrad. Universitet. Nauchno-Issledovatel'skiĭ Institut Zemnoĭ Kory
Voprosy Paleontologii
Leningrad. Vsesoiżnỳ Neftianoi Nauchno-Issledovatel'skiĭ Geologorazvedochnyi Institut
Trudy. Novaia seriia

ASIA
JAPAN
Hokkaido University, Sapporo. Faculty of Science.
Journal. Series 4: Geology and Mineralogy
Kyushu University, Fukuoka. Faculty of Science
* Memoirs. Series D: Geology
Tohoku University, Sendai
Contributions from the Institute of Geology and Paleontology
Science Report. Second Series (Geology)
Tokyo. University. Faculty of Science
Journal. Section 2: Geology, mineralogy, geography, seismology

AFRICA
MOZAMBIQUE
Estudos Gerais Universitários de Moçambique, Lourenço Marques
Revista de ciências geológicas

AUSTRALIA AND OCEANIA
AUSTRALIA
Queensland University. Department of Geology, Brisbane
Papers

NEW ZEALAND
Wellington, New Zealand. Oceanographic Institute
NZOI Records

M U S E U M S
NORTH AMERICA
CANADA
Canada. National Museum, Ottawa
* Bulletin (Title varies: Victoria Memorial Museum Bulletin, Museum Bulletin, etc.)
Toronto. Royal Ontario Museum. Life Sciences Division
Contributions
UNITED STATES (INDIVIDUAL)
ARIZONA
Flagstaff, Ariz. Museum of Northern Arizona
Bulletin
CONNECTICUT
Yale University. Peabody Museum of Natural History
Bulletin
DISTRICT OF COLUMBIA
U.S. National Museum, Washington, D.C.
* Bulletin
* Proceedings
FLORIDA
Florida. University, Gainesville. State Museum
Bulletin. Biological Sciences
HAWAII
Bernice Pauahi Bishop Museum, Honolulu
Bulletin
ILLINOIS
Chicago. University. Walker Museum
Contributions
Memoirs
Field Museum of Natural History, Chicago
Fieldiana: Geology, Memoirs
Publications
Illinois. State Museum of Natural History, Springfield
Bulletin
MASSACHUSETTS
Harvard University. Museum of Comparative Zoology, Cambridge
Breviora
Bulletin. Paleontology
Memoirs
MICHIGAN
Michigan. University. Museum of Paleontology, Ann Arbor
Contributions
Michigan. University. Museum of Zoology, Ann Arbor
Miscellaneous Publications
Occasional Papers
NEW YORK
American Museum of Natural History, New York.
American Museum Novitates

NEW YORK (Cont.)
American Museum of Nat. History (Cont.)
Bulletin
The Curator
Memoirs
Natural History: the journal of the American Museum
New York. State Museum and Science Service, Albany
Annual Report
* Bulletin
Educational Leaflet
Handbook
* Memoir
OHIO
Cleveland. Museum of Natural History
The Explorer
PENNSYLVANIA
Pittsburgh. Carnegie Institute Museum
Annals
WISCONSIN
Milwaukee. Public Museum
Bulletin

SOUTH AMERICA
ARGENTINA
Buenos Aires. Museo Argentino de Ciencias Naturales 'Bernardino Rivadavia'
Anales
URUGUAY
Montevideo, Museo de Historia Natural
Comunicaciones paleontológicas

EUROPE
BELGIUM
Brussels. Musée Royal d'Histoire Naturelle de Belgique
* Annales
* Mémoires
Tervuren, Belgium. Musée du Congo Belge
Annales. Sér. in-8 . Sciences géologiques
ENGLAND
British Museum (Natural History) London
* Bulletin. Geology
Publications
FRANCE
Lyons. Muséum d'Histoire Naturelle
Archives
HUNGARY
Budapest. Magyar Nemzeti Múzeum
Annales historico-naturales
Budapest. Természettudomanyi Múzeum
Fragmenta mineralogica et palaeontologica
NETHERLANDS
Leyden. Rijks Geologisch-Mineralogisch Museum
Sammlungen des Geologischen Reichs-Museums in Leiden. (Superseded in 1925 by Leidsche Geologische Mededelingen)
POLAND
Warsaw. Muzeum Ziemi
Acta Geologica Polonica
PORTUGAL
Coimbra, Portugal. Universidade. Museu Mineralógico e Geológico
Publicações; Memórias e Notícias

AFRICA
South African Museum, Cape Town
Annals

AUSTRALIA AND OCEANIA
AUSTRALIA
Queensland Museum, Brisbane
Memoirs

OTHER SERIALS (ISSUED BY BOOK PUBLISHERS, PRIVATE SOURCES, ETC.)
NORTH AMERICA
CANADA
The Canadian Naturalist and Quarterly Journal of Science. (Superseded by Canadian Record of Science) (Montreal)
UNITED STATES
The American Geologist (1888-1905; 1906 merged into Economic Geology; 1922, Pan American Geologist) (Minneapolis)
Earth Science (Colorado Springs, Colo.)
Journal of Geology (Chicago)
Rocks and Minerals (Peekskill, N.Y.)
* Sterkiana (Columbus, Ohio)

SOUTH AMERICA
ARGENTINA
Boletín Paleontológico de Buenos Aires (Buenos Aires)

EUROPE
AUSTRIA
Palaeobiologica (Vienna)
Tschermaks mineralogische und petrographische Mitteilungen (Vienna)
ENGLAND
Advances in marine biology (London)
Deep-sea Research and Oceanographic Abstracts (Oxford)
Estuarine and coastal marine science (London)
Geochimica et Cosmochimica Acta (Oxford)
The Geological Magazine (Hertford)
The Geologist (London)
Nature (London)
Nature (Physical Science) (London)
FRANCE
* Annales de paléontologie (In 1963, superseded by Annales de paléontologie. Série vertébrés (and) ... Série invertébrés (Paris)
* Journal de Conchyliologie (Paris)
GERMANY
Fortschritte der Geologie und Palaeontologie (Berlin)
Geologie (Berlin)
Geologische und palaeontolpgische Abhandlungen (Jena)
Geologisches Archiv (Königsberg)

GERMANY (Cont.)
Jahrbuch für Geologie (Berlin)
* Neues Jahrbuch für Geologie und Paläontologie. Abhandlungen. (Stuttgart)
Monatshefte (Stuttgart)
* Palaeontographica (Stuttgart)
* Paläontologische Zeitschrift (Berlin)
ITALY
* Annales de géologie et de paléontologie (Ceased publication in 1930). (Palermo)
* Palaeontographia Italica (Pisa)
Quaternaria; storia naturale e culturale del Quaternario (Rome)
NETHERLANDS
Earth Science Reviews (Amsterdam)
Marine Geology (Amsterdam)
Palaeogeography, Palaeoclimatology, Palaeoecology (Amsterdam)
Sedimentary Geology (Amsterdam)
Tectonophysics (Amsterdam)
SPAIN
Revista española de micropalaeontología (Madrid)
SWITZERLAND
Eclogae Geologicae Helveticae (Basel)

ASIA
JAPAN
Atlas of Japanese Fossils (Tokyo)

PROCEEDINGS OF INTERNATIONAL MEETINGS
Congrès International de Stratigraphie et de Géologie du Carbonifère. Compte Rendu (Paris)
International Geological Congress
* Reports (Published at the site of the Congress)

FIELD TRIP GUIDE BOOKS
Geological societies prepare field trip guide books for their annual meetings. In these regional studies, there is often mention of local fossils. Examples of such publications are the Geological Society of America's Guidebook for field trips *and the Society of Economic Paleontologists and Mineralogists'* Guidebook for annual field trip.

GENERAL TREATISES

ABBOTT, Robert Tucker (1954) American seashells. (The New Illustrated Naturalist) Princeton, N.J., Van Nostrand. 541 p.

ABEL, Othenio (1916) Paläobiologie der Cephalopoden aus der Gruppe der Dibranchiaten. Jena, G. Fischer. 282 p.

AKADEMIIA NAUK GRUZINSKOĬ SSR, TIFLIS. INSTITUT PALEOBIOLOGII (1966) Spravochnik po ekologii morskikh dvustvorok. Moskva, Nauka. 351 p.

BAKER, Frank Collins (1969 reprint of 1920 ed.) The life of the Pleistocene or Glacial Period as recorded in the deposits laid down by the great ice sheets. New York, AMS Press. 476 p.

---- (1945) The molluscan family Planorbidae. Collation, revisions, and additions by Harley Jones Van Cleave. Urbana, University of Illinois Press. 530 p.

BALASHOV, Zakhar Grigor'evich (1968) Endotseratoidei Ordovika SSSR. Leningrad, Leningrad Universitet. 278 p.

BENNETT, ISOBEL (1966) The fringe of the sea. Adelaide, Australia, Rigby. 261 p.

BIGSBY, John Jeremiah (1868) Thesaurus siluricus. The flora and fauna of the Silurian Period, with addenda (from recent acquisitions) London, J. Van Voorst. 214 p.

---- (1878) Thesaurus devonico-carboniferus. The flora and fauna of the Devonian and Carboniferous Periods. London, J. Van Voorst 448 p.

Biology and geology of coral reefs (1973-) New York, Academic Press. Vol. 1--

BORRELLO, Angel V., ed. (1966) Palaeontografia bonaerense. Fasciculo 3. Invertebrados, by Horacio H. Camacho. La Plata, Provincia de Buenos Aires, Comisión de Investigación Científica. 159 p.

BOWEN, Robert Napier Clive (1966) Palaeotemperature analysis. (Methods in geochemistry and geophysics, 2) Amsterdam, New York, Elsevier. 265 p.

BUCKMAN, Sydney Savory (1887-1907) A monograph of the Ammonites of the 'Inferior Oolite Series' (Stages - Toarcian, pars; Aalenian; Bajocian; Bathonian, pars) London, Printed for the Palaeontographical Society. 2 vols.

CADART, Jean (1955) Les escargots (*Helix pomatia* L. et *Helix aspersa* M.); biologie, élevage, parcage, histoire, gastronomie, commerce. (Savoir en histoire naturelle, v. 24) Paris, P. Lechevalier. 420 p.

CAMACHO, Horacio H. (1966) Invertebrados fósiles. Rev. (Manuales de EUDEBA, Ciencias Naturales) Buenos Aires, Editorial Universitaria de Buenos Aires. 707 p.

CANADA, GEOLOGICAL SURVEY (1865-1906) Palaeozoic Fossils. Montreal, Dawson, 4 vols.

CARSON, Rachel Louise (1955) The edge of the Sea. Boston, Houghton Mifflin. 276 p.

CASE, Gerard Ramon (1968) Fossils illustrated; an atlas of invertebrate and vertebrate fossils. New York. Grafco. 32 p.

CÉLÉBONOVIČ, Stévan (1957?) The living Rocks. Translations by Joyce Emerson and Stanley A. Pocock. (Art and Nature) London, Phoenix House. 94 p.

CHAVAN, André (1957) Détermination pratique des fossiles, par André Chavan et André Cailleux. Paris, Masson. 387 p.

CHEMIN, Émile (1926) Les mollusques d'eau douce. (Encyclopédie pratique du naturaliste, 24) Paris. P. Lechevalier. 185 p.

DAVIES, Arthur Morley (1934) Tertiary faunas, a text-book for oilfield palaeontologists and students of geology. London, T. Murby. 2 vols. (2d ed. published in 1971 by Allen and Unwin, London; 2 vols.)

DECUGIS, Henri (1941) Le vieillissement du monde vivant. Paris, Plon. 385 p.

DENYS DE MONTFORT, Pierre (1801-1805) Histoire naturelle, générale et particulière des mollusques, animaux sans vertèbres et à sang blanc. Paris, F. Dufart. 6 vols.

DEZALLIER D'ARGENVILLE, Antoine Joseph(1755) L'Histoire naturelle éclaircie dans une de ses parties principales, l'Oryctologie, qui traite des terres, des pierres, des métaux, des minéraux, et autres fossiles, ouvrage dans lequel on trouve une nouvelle méthode latine et françoise de les diviser, et une notice critique des principaux ouvrages qui ont paru sur ces matières. Paris, chez De Bure l'Aîné. 560 p.

EDMONDSON, Walles Thomas (1959) Fresh-water Biology. 2d ed. New York, Wiley. 1248 p.

Essays in Paleontology and Stratigraphy; R. C. Moore Commemorative Volume (1967) Edited by Curt Teichert and Ellis L. Yochelson. (Kansas. University. Department of Geology. Special Publication 2) Lawrence, University of Kansas Press. 626 p.

The Fossil Record; a Symposium with Documentation (1967) Edited by W.B. Harland and others. Jointly sponsored by the Geological Society of London and the Palaeontological Association. London, Geological Society of London. 827 p.

Fuer die Litteratur und Kenntniss der Naturgeschichte, sonderlich der Conchylien und der Steine (1782). Weimar, C.L. Hoffman. 2 vols. in 1

GAUDRY, Albert (1878-1890) Les enchainements du monde animal dans les temps géologiques. Paris, Hachette, 3 vols.

GEINITZ, Hanns Bruno (1846) Grundriss der Versteinerungskunde. Dresden, Arnoldische Buchhandlung. 813 p.

GRABAU, Amadeus William (1935) Studies of Gastropoda. Peking (Peiping) China, The National University of Peking, The University Press. 159 p.

GROSSOUVRE, Albert de (1893-1901) Recherches sur la craie supérieure. (France. Service de la carte géologique. Mémoires pour servir à l'explication de la carte géologique détaillée de la France) Paris, Imprimerie Nationale, 2 vols. in 3.

HIND, Wheelton (1894-1896) A monograph on *Carbonicola, Anthracomya,* and *Naiadites*. London, Printed for the Palaeontographical Society. 3 vols.

IMBRIE, John, ed. (1964) Approaches to paleoecology. Edited by John Imbrie and Norman Newell. New York, Wiley, 432 p.

INTERNATIONAL GEOLOGICAL CONGRESS, 23d, Prague, 1968 (1972) Proceedings of the International Paleontological Union: Evolution, Ostracoda, Paleoecology and Paleobiogeography, other subjects. Warszawa, Instytut Geologiczny, Wydawnictwa Geologiczne. 441 p.

INTERNATIONAL SYMPOSIUM ON THE DEVONIAN SYSTEM, CALGARY, 1967 (1967) International Symposium on the Devonian System, Calgary, 1967; papers. D. H. Oswald ed., Calgary, Alberta Society of Petroleum Geologists. 2 vols.

Journal fuer die Liebhaber des Steinreichs und der Konchyliologie (1773-1780) Weimar, C. L. Hoffman. 6 vols.

LAPORTE, Léo F. (1968) Ancient Environments. (Foundations of Earth Science series) Englewood Cliffs, N.J., Prentice-Hall. 115 p.

MAJEWSKE, Otto P. (1969) Recognition of invertebrate fossil fragments in rocks and thin sections. (Thesis, Ph.D., Louisiana State University) Baton Rouge; photocopy, University Microfilms, Ann Arbor, Mich. 1970. 266 p.

MARTIN, William (1809) Outlines of an attempt to establish a knowledge of extraneous fossils, on scientific principles. Macclesfield, Printed by J. Wilson. 250 p.

MILLER, Samuel Almond (1889) North American Geology and Paleontology for the use of amateurs, students, and scientists. Cincinnati, Western Methodist Book Concern. 664 p. (1st appendix, 1892, p. 665-718; 2d appendix, 1897, p. 719-793)

MILNE-EDWARDS, Henri (n.d.) Monographie des Polypiers fossiles des terrains Palaeozoïques, précédée d'un tableau général de la classification des Polypes, par MM. Milne-Edwards et Jules Haime. (Extrait du tome 5 des Archives du Muséum d'Histoire naturelle) Paris, Gide et J. Baudry. 502 p.

MOORE, Raymond Cecil (1952) Invertebrate Fossils, by Raymond C. Moore, Cecil G. Lalicker, and Alfred G. Fischer. New York, McGraw-Hill. 766 p.

NAEF, Adolf (1922) Die fossilen Tintenfische Eine paläozoologische Monographie. Jena, G. Fischer. 322 p.

Neue Litteratur und Beytraege zur Kenntniss der Naturgeschichte, vorzueglich der Conchylien und Fossilien (1784-1787) Leipzig, J. G. Müllerschen. 4 vols.

OWEN, Richard (1861) Palaeontology, or, A systematic summary of extinct animals and their geological relations. 2d ed. Edinburgh, A. and C. Black. 463 p.

PAINVIN, Georges Jean (1941?) Embranchement des Mollusques, v. 3: Céphalopodes. (His Cahiers de Paléontologie, 3). Paris, Masson. 55 p.

PAPP, Adolf (1959) Tertiär, von A. Papp und E. Thenius. (Handbuch der stratigraphischen Geologie, Bd. 3, T. 1-2) Stuttgart, F. Enke. 2 vols.

PARKINSON James (1804-1811) Organic remains of a former world. An examination of the mineralized remains of the vegetables and animals of the antediluvial world; generally termed extraneous fossils. London, J. Robson. 3 vols. (2d ed. published in 1833 by M.A. Nattali, London; 3 vols.)

---- (1822) Outlines of Oryctology. An introduction to the study of fossil organic remains, especially those found in the British strata; intended to sid the student in his enquiries respecting the nature of fossils, and their connection with the formation of the earth. London., The Author. 349 p.

PEARSON, Ronald George (1964) Animals and plants of the Cenozoic era; some aspects of the faunal and floral history of the last sixty million years. London, Butterworths. 236 p.

PIA, Julius (1933) Die rezente Kalksteine. (Added title page: Zeitschrift für Kristallographie, Mineralogie und Petrographie, Abt. B: Mineralogische und petrographische Mitteilungen. Ergänzungsband) Leipzig, Akademische Verlagsgesellschaft M.B.H. 420 p.

PICTET, François Jules (1853-1872) Traité de Paléontologie; ou Histoire naturelle des animaux fossiles considérés dans leurs rapports zoologiques et géologiques. 2d ed., rev., cor., considérablement augm., accompagnée d'un atlas de 110 planches, grand in-4°. Paris, J. B. Baillière. 4 vols.

PIVETEAU, Jean (1952-1957) Traité de Paléontologie. Paris, Masson, 7 vols. in 10

PURCHON, Richard Denison (1968) The Biology of the Mollusca. (International Series of Monographs in pure and applied Biology. Division: Zoology, v. 40) Oxford, New York, Pergamon Press. 560 p.

RAVEN, Christiaan Pieter (1966) Morphogenesis; the analysis of molluscan development. 2d ed. (International Series of Monographs on pure and applied Biology. Division: Zoology, v. 2) Oxford, New York, Pergamon Press. 365 p.

RICHARDS, Horace Gardiner (1938) Animals of the Seashore. Boston, B. Humphries. 273 p.

ROGERS, Julia Ellen (1913) The Shell Book; a popular guide to a knowledge of the families of living mollusks, and an aid to the identification of shells native and foreign. New York, Doubleday, Page. 485 p. (Rev. ed. published in 1936 by C. T. Branford, Boston, 503 p.)

ROMAN, Frédéric (1938) Les Ammonites: jurassiques et crétacées. Paris, Masson. 554 p.

SELLEY, Richard C. (1970) Ancient sedimentary environments; a brief survey. Ithaca, N. Y., Cornell University Press. 237 p.

Sexual Dimorphism in fossil Metazoa and taxonomic implications (1968) Symposium organized by the International Palaeontological Union, Committee on Evolution, Prague. Ed. by Gerd Ernst Gerold Westermann. (International Union of Geological Sciences. Series A, No. 1) Stuttgart, Schweizerbart (Nägele u. Obermiller) 250 p.

SMITH, Bertie Webster (1940) The World under the Sea; a concise account of the marine world. New York, London, Appleton-Century. 230 p.

SPOEHL, Siebrecht van der (1967) Euthecosomata. A group with remarkable developmental stages. (Gastropoda, Pteropoda) Gorinchem, J. Noorduijn. 375 p.

SYLVESTER-BRADLEY, Peter Colley (1967 reprint of 1956 ed.) The species concept in Palaeontology; a symposium edited for the Association by P.C. Sylvester-Bradley. (Systemstics Association. Publication No. 2) London, Systematics Association. 145 p.

TERMIER, Henri (1960) Paléontologie stratigraphique par H. Termier et G. Termier. Paris, Masson. 515 p.

---- (1964) Les Temps Fossilifères; Traité de Stratigraphie et de Paléogéographie, t. 1: Paléozoïque inférieur, par Henri Termier et Geneviève Termier. Paris, Masson, 689 p.

---- (1968) Biologie et Écologie des premiers Fossiles par Henri Termier et Geneviève Termier. (Collection Les Grands Problèmes de la Biologie, Monographie 8) Paris, Masson. 214 p.

THORPE, Malcolm Rutherford, ed. (1924) Organic adaptation to environment, by George Elwood Nichols *et al.* New Haven, Yale University Press. 312 p.

TWENHOFEL, William Henry (1935) Invertebrate Paleontology, by William H. Twenhofel and Robert R. Shrock. New York, London, McGraw-Hill. 511 p. (2d ed. entitled *Principles of Invertebrate Paleontology* published in 1953 by McGraw-Hill, New York, 816 p.)

VOLTZ, Philippe Louis (18--?) Observations sur les *Belopeltis*, ou lames dorsales des Bélemnites. (Extracted from the Mémoires of the Société des Sciences de Nancy, t. 3, livr. 1) n.p. 38 p.

WEDEKIND, Rudolf (1916) Über die Grundlagen und Methoden der Biostratigraphie. Berlin, Gebrüder Borntraeger. 60 p.

WENZ, Wilhelm (1938) Gastropoda. (Handbuch der Paläozoologie, Bd. 6 I) Berlin, Gebrüder Borntraeger. 2 vols.

WILLIAMS, Henry Shaler (1895) Geological biology: an introduction to the geological history of organisms. New York, H. Holt. 395 p.

WILSER, Julius (1931) Lichtreaktionen in der fossilen Tierwelt; versuch einer Paläophotobiologie. Berlin, Gebrüder Borntraeger. 192 p.

WISE, Sherwood Willing (1970) Scanning electron microscope study of molluscan shell ultrastructures. (Thesis, Ph.D., University of Illinois) Urbana; photocopy, University Microfilms, Ann Arbor, Mich., 1971. 139 p.

ZEUNER, Friedrich Eberhard (1959) The Pleistocene Period; its climate, chronology, and faunal successions. London, Hutchinson. 447 p.

REGIONAL STUDIES

See also the citations under 'Catalogs and Collections' in the 'Guide to Information Sources' section.

THE WORLD

ARKELL, William Joscelyn (1956) Jurassic geology of the World. New York, Hafner, 806 p.

SHERLOCK, Robert Lionel (1948) The Permo-Triassic Formations, a world review. London, Hutchinson. 367 p.

POLAR REGIONS

ANTARCTICA

BRITISH, AUSTRALIAN AND NEW ZEALAND ANTARCTIC RESEARCH EXPEDITION, 1921-1931 (1937-

1962) Reports. Series B. Adelaide; B.A.N.Z. A.R. Committee. 9 vols.

CHARCOT, Jean Baptiste Auguste Étienne (1906) Mollusques. (Expédition Antarctique Française (1903-1905) commandée par Jean Charcot. Sciences naturelles: documents scientifiques) Paris, Masson, 84 p.

HADLEY, Jarvis Bardwell, ed. (1965) Geology and Paleontology of the Antarctic. (American Geophysical Union. Antarctic Research Series, v. 6; National Research Council. Publication No. 1299) Washington, D.C., American Geophysical Union. 281 p.

JOUBIN, Louis Marie Adolphe Olivier Édouard. Némertiens, céphalopodes, brachiopodes, par J. (i.e., L.) Joubin. Alcyonaires, madréporaires, par Ch. Gravier. Hydroïdes, par Armand Billard. Oiseaux antarctiques, par L. Gain. (Deuxième Expédition Antarctique Française (1908-1910) commandée par Jean Charcot. Sciences naturelles: documents scientifiques) Paris, Masson. 408 p.

LAMY, Édouard (1911) Gastropodes prosobranches, Scaphopodes et Pélécypodes. Amphineures par Joh. Thiele. (Deuxième Expédition Antarctique Française (1908-1910) commandée par Jean Charcot. Sciences naturelles: documents scientifiques) Paris, Masson. 34 p.

TOPSENT, Émile Eugène Aldric (1917) Spongiaires, par E. Topsent. Mollusques Amphineures et gastéropodes, par A. Vayssière. Crustacés schizopodes et décapodes, par M. Coutière. Cumacés par W.-J. Calman. Acariens, par A. Berlese. Minéralogie-géologie, par E. Gourdon. (Deuxième Expédition Antarctique Française (1908-1910) commandée par Jean Charcot. Sciences naturelles: documents scientifiques) Paris, Masson. 166 p.

THE ARCTIC

CANADIAN ARCTIC EXPEDITION, 1913-1918 (1924) Report, vol. 11: Geology and Geography. Ottawa. 164 p.

DAUTZENBERG, Philippe (1911) Mollusques et brachiopodes recueillis en 1908 par la Mission Bénard dans les mers du Nord (Nouvelle-Zemble, Mer de Barents, Mer Blanche, Océan Glacial, Norvège, Mer du Nord) par Ph. Dautzenberg et H. Fischer. Paris (Extrait du Bulletin du Muséum d' Histoire Naturelle, n. 3, p. 143-146)

LIŪTKEVICH, Evgeniĭ Mikhaĭlovich (1968) Permian pelecypods of the Soviet sector of the Arctic. Trans. from Russian of Peletsipody Permi Sovetskogo sektora arktiki: Trudy Vsesoyznogo Neftyanogo Nauchno-Issledovatel'skogo Geologorazvedochnogo Instituta (VNIGRI) vyp. 149 1960; by E. M. Liūtkevich and O. V. Lobanova. Trans. by Kenneth Syers; ed. by Alan Logan. Boston Spa, Eng., National Lending Library for Science and Technology. 2 vols.

NORSKE VIDENSKAPS-AKADEMI I OSLO (1907-1919) Report of the Second Norwegian Arctic Expedition in the 'Fram' 1898-1902. Kristiania, Published by Videnskabs-selskabet i Kristiania, in commission by T.O. Brøgger. 4 vols.

NORTH AMERICA

NORTH AMERICA (IN GENERAL)

CONRAD, Timothy Abbott (1893) Republication of Conrad's fossil shells of the Tertiary formations of North America. Washington, D.C., R. H. Darby. 121 p.

NORTH AMERICAN PALEONTOLOGICAL CONVENTION, CHICAGO, 1969 (1970-) Proceedings. Part A- Lawrence, Kansas, Allen Press

WHITE Charles Abiathar (1883) A review of the non-marine fossil Mollusca of North America. Washington, D. C., Gov't Prtg. Office (Extract from the Third Annual Report of the Director of the U.S. Geological Survey, 1881-1882, p. 403-550)

NORTH AMERICA (SPECIFIC REGIONS)

ATLANTIC COAST

AGASSIZ, Alexander (1888) A contribution to American Thalassography. Three cruises of the United States Coast and Geodetic Survey Steamer 'Blake,' in the Gulf of Mexico, in the Caribbean Sea, and along the Atlantic Coast of the United States, from 1877 to 1880. Boston, Houghton, Mifflin. 2 vols.

MORRIS, Percy A. (1947) A field guide to the shells of our Atlantic Coast. (Field Guide series) Boston, Houghton, Mifflin. 190 p.

TRYON, George Washington (1873) American marine Conchology, or, Descriptions of the shells of the Atlantic Coast of the United States from Maine to Florida. Philadelphia, The Author. 208 p.

PACIFIC COAST

KEEN, Angeline Myra (1958) Sea shells of Tropical West America; marine mollusks from Lower California to Colombia. Stanford, Calif., Stanford University Press. 624 p.

RICKETTS, Edward Flanders (1948) Between Pacific Tides, an account of the habits and habitats of some five hundred of the common, conspicuous seashore invertebrates of the Pacific Coast between Sitka, Alaska, and northern Mexico, by Edward F. Ricketts and Jack Calvin. Rev. ed. Stanford, Calif., Stanford University Press. 365 p.

THE WEST

KEEP, Josiah (1935) West Coast Shells; a description in familiar terms of principal marine, freshwater, and land mollusks of the United States, British Columbia, and Alaska, found west of the Sierra. Revised by Joshua L. Baily, Jr. Stanford, Calif., Stanford University Press; London, H. Milford, Oxford University Press. 350 p.

A Symposium on Paleoenvironments of the Cretaceous seaway in the Western Interior (1967) Preprints of papers to be presented ... in conjunction with the twentieth annual meeting, the Geological Society of America, Rocky Mountain Section, Colorado School of Mines, May 10, 1967. Golden, Colo., Dept. of Publications, Colorado School of Mines. 266 p.

CANADA (IN GENERAL)
DAWSON, John William (1897) The Canadian Ice Age: being notes on the Pleistocene geology of Canada, with especial reference to the life of the period and its climatal conditions. Montreal, W. V. Dawson. 301 p.

CANADA (PROVINCES)
ONTARIO
BICKEL, Edwin David (1970) Pleistocene non-marine Mollusca of the Gatineau Valley and Ottawa areas of Quebec and Ontario, Canada. (Thesis, Ph.D., The Ohio State University) Columbus. 182 p.
CLOWERS, Stanley Robert (1966) Pleistocene Mollusca of the Box Marsh deposit, Admaston Township, Renfrew County, Ontario, Canada. (Thesis, M.S., The Ohio State University) Columbus. 85 p.
NICHOLSON, Henry Alleyne (1874) Report upon the Palaeontology of the Province of Ontario. Toronto, Hunter, Rose. 133 p.
---- (1875) Report upon .... supplementary to the text published in 1874. Toronto, Hunter, Rose. 96 p.
QUEBEC
BICKEL, Edwin David (1970) *(See citation under 'Ontario')*
BILLINGS, Elkanah (1964 reprint of the original, published by the Geological Survey of Canada, November 1866) Catalogues of the Silurian fossils of the Island of Anticosti, with descriptions of some new genera and species. (Auxilia Palaeontologiae, No. 1) n.p. 64 p.
GIBSON, Gail Guy (1967) Pleistocene non-marine Mollusca of the Richardson Lake deposit, Clarendon Township, Pontiac County, Quebec, Canada. (Thesis, M. S., The Ohio State University) Columbus. 119 p.
SHALLOM, Lizzie Jacob (1965) Pleistocene molluscan fauna of the Lac Blanc deposit, Matapedia County, Quebec, Canada. (Thesis, M.S., The Ohio State University) Columbus. 57 p.

UNITED STATES (IN GENERAL)
LEA, Isaac (1833) Contributions to Geology. Philadelphia, Carey, Lea and Blanchard. 227 p.
MORTON, Samuel George (1834) Synopsis of the organic remains of the Cretaceous Group of the United States. Philadelphia, Key and Biddle. 108 p.
MURRAY, Marian (1967) Hunting for fossils; a guide to finding and collecting fossils in all fifty states. New York, Macmillan. 348 p.
U.S. GEOGRAPHICAL SURVEYS WEST OF THE 100TH MERIDIAN (1874) Preliminary report upon invertebrate fossils collected by the expeditions of 1871, 1872, and 1873, with descriptions of new species. C. A. White, M. D. Washington, D. C., Govt. Prtg. Office 27 p.

UNITED STATES (INDIVIDUAL)
ALABAMA
LEWIS, James (1876?) Fauna of Alabama. 1. Fresh water and land shells. Montgomery, Geological Survey of Alabama. 42 p.
CALIFORNIA
ARNOLD, Ralph (1903) The Paleontology and Stratigraphy of the marine Pliocene and Pleistocene of San Pedro, California. (Thesis, Ph. D., Leland Stanford Jr. University, 31) Stanford, Calif., Stanford University. 420 p.
FRÉMONT, John Charles (1845) Report of the Exploring Expedition to the Rocky Mountains in the year 1842, and to Oregon and North California in the years 1843-1844. (U. S. 28th Congress, 2d sess. Senate. Ex. Doc. 174) Washington, D. C., Gales and Seaton. 693 p.
KLEINPELL, Robert Minssen (1938) Miocene Stratigraphy of California. Tulsa, American Association of Petroleum Geologists; London, T. Murby. 450 p.
SCHENCK, Hubert Gregory (1950) California Fossils for the field geologist, by Hubert G. Schenck and A. Myra Keen. Stanford, Calif., Stanford University Press. 88 p.
FLORIDA
WARMKE, Germaine Le Clerc (1962) Caribbean Seashells; a guide to the marine mollusks of Puerto Rico and other West Indian islands, Bermuda and the Lower Florida Keys, by Germaine L. Warmke and R. Tucker Abbott. Narberth, Pa., Livingston. 348 p.
ILLINOIS
GREACEN, Katherine F., comp. (1946) Silurian invertebrate fossils from Illinois in the Thomas A. Greene Memorial Museum at Milwaukee-Downer College. Compiled by Katherine F. Greacen and John R. Ball. (Milwaukee-Downer College Bulletin) Milwaukee. 61 p.
ILLINOIS STATE GEOLOGICAL SURVEY (1866-1890) Geological Survey of Illinois. Springfield, State Journal Steam Press. 8 vols. in 9.
INDIANA
COLLETT, John (1881) Indiana Geological Report, 1879-1880. From the Second Annual Report of the Bureau of Statistics and Geology. Indianapolis, Carlon and Hollenbeck. 164 p.
CUMINGS, Edgar Roscoe (1907) The Stratigraphy and Paleontology of the Cincinnati Series of Indiana. (Extracted from the 32d Annual Report of Indiana, Dept. of Geology and Natural Resources, p. 605-1258) n.p.
GREENE, George K. (1898-1906) Contribution to Indiana Paleontology. New Albany, Indiana, Ewing and Zeller. 2 vols. in 5.
NAVE, Floyd Roger (1968) Pleistocene Molluscs of Southwestern Ohio and Southeastern Indiana. (Thesis Ph.D., The Ohio State University) Columbus. 157 p.
IOWA
THE MUSCATINE CONCHOLOGICAL CLUB, Muscatine, Iowa (1883) The Mollusca of Muscatine County and vicinity. Boston, S. E. Cassino, 24 p.
KENTUCKY
KENTUCKY GEOLOGICAL SURVEY (1856-1861) First-fourth Report of the Geological Survey in Kentucky made during the years 1854 to 1859

by David Dale Owen. Frankfort, A. G. Hodges. 4 vols.

---- (1889) Kentucky fossil shells; a monograph of the fossil shells of the Silurian and Devonian rocks of Kentucky, by Henry Nettelroth. Frankfort, E.P. Johnson. 295 p.

MASSACHUSETTS

GOULD, Augustus Addison (1870) Report on the Invertebrata of Massachusetts, published agreeably to an order of the Legislature. 2d ed., comprising the Mollusca. Ed. by W. G. Binney. Boston, Wright and Potter. 524 p.

GRABAU, Amadeus William, ed. (1898) Guide to localities illustrating the geology, marine zoology, and botany of the vicinity of Boston. Ed. by A. W. Grabau and J. E. Woodman. Boston, American Association for the Advancement of Science. 100 p.

MINNESOTA

MINNESOTA GEOLOGICAL AND NATURAL HISTORY SURVEY (1884-1901) The Geology of Minnesota. Vol. 1-6 of the Final Report. St. Paul, Pioneer Press. 6 vols. in 7.

NEW JERSEY

NEW JERSEY GEOLOGICAL SURVEY (1886-1907) Report on Paleontology. Trenton. 4 vols. in 5.

NEW MEXICO

NEWELL, Norman Dennis (1953) The Permian Reef Complex of the Guadalupe Mountains Region, Texas and New Mexico; a study of Paleoecology, by Norman D. Newell *et al.* San Francisco, W. H. Freeman. 287 p.

U.S. ARMY CORPS OF ENGINEERS (1876) Report of the Exploring Expedition from Santa Fe, New Mexico, to the junction of the Grand and Green rivers of the Great Colorado of the West, in 1859, under the command of Capt. J.N. Macomb, Corps of Topographical Engineers ... with geological report by Prof. J.S. Newberry. Washington, Govt. Prtg. Office. 168 p.

WENDORF, Fred, ed. (1961) Paleoecology of the Llano Estacado. (Publication of the Fort Burgwin Research Center, No. 1) Santa Fe, Museum of New Mexico Press. 144 p.

NEW YORK

HALL, James (1964) Preliminary Notice of the Lamellibranchiate shells of the Upper Helderberg, Hamilton and Chemung groups, with others from the Waverly sandstones (by Hall and Whitfield). (Auxilia Palaeontologiae, No. 2) n. p. 64 p.

LEUTZE, Willard Parker (1959) Stratigraphy and Paleontology of the Salina Group in Central New York. (Thesis, Ph.D., The Ohio State University) Columbus. 463 p.

NEW YORK (STATE) NATURAL HISTORY SURVEY (1847-1894) Palaeontology of New York, by James Hall. Albany, Printed by C. Van Benthuysen. 8 vols. in 13

OHIO

AUKEMAN, Frederick Neil (1960) Pleistocene molluscan faunas of the Oakhurst deposit, Franklin County, Ohio. (Thesis, M.S., The Ohio State University) Columbus. 145 p.

BOWMAN, Richard Spencer (1956) Stratigraphy and Paleontology of the Niagaran Series in Highland County, Ohio. (Thesis, Ph.D., The Ohio State University) Columbus. 340 p.

BUCHER, Walter Herman (1945) Elementary Guide to the fossils and strata in the vicinity of Cincinnati. Cincinnati, The Cincinnati Museum of Natural History. 31 p.

---- (1955) Elementary guide to the fossils and strata of the Ordovician in the vicinity of Cincinnati, Ohio. Revised by Kenneth E. Caster *et al.* Cincinnati, The Cincinnati Museum of Natural History. 47 p.

CLARK, Armin Lee (1958) Pleistocene molluscan faunas of the Castalia deposit, Erie County, Ohio. (Thesis, M.S., The Ohio State University) Columbus. 129 p.

CORNEJO, John (1959) Pleistocene molluscan faunas of the Souder Lake deposit, Franklin County, Ohio. (Thesis, M. S., The Ohio University) Columbus. 146 p.

FAGADAU, Sanford Payne (1952) Paleontology and Stratigraphy of the Logan Formation of Central and Southern Ohio. (Thesis, Ph. D., The Ohio State University) Columbus. 425 p.

JAMES, Uriah Pearson (1871) Catalogue of the Lower Silurian fossils, Cincinnati Group, found at Cincinnati and vicinity—within a range of forty or fifty miles. Cincinnati, The Author. 14 p.

LAMBORN, Helen (Morningstar) (1915) The Fauna of the Niagaran Series in Ohio. (Thesis, M.A., The Ohio State University) Columbus. 143 p.

---- (1921) The fauna of the Pottsville Formation of Ohio below the Lower Mercer Limestone. (Thesis, Ph.D., Bryn Mawr College) n. p. 92 p.

MORSE, W. C. (1911) The fauna of the Maxville Limestone. (Proceedings of the Ohio State Academy of Science, v. 5, pt. 7. Special Paper No. 17, p. 353-420) Columbus, Ohio State Academy of Science.

MOWERY, Dale Harris (1958) Pleistocene molluscan faunas of the Jewell Hill deposit, Logan County, Ohio. (Thesis, M. S., The Ohio State University) Columbus. 154 p.

NAVE, Floyd Roger (1968) *(See citation under 'Indiana')*

REYNOLDS, Martin Bruce (1958) Pleistocene molluscan faunas of the Humboldt deposit, Ross County, Ohio. (Thesis, M. S., The Ohio State University) Columbus. 101 p.

RODRIGUEZ, Joaquin (1957) Paleontology of the Mississippian Formations of Knox County, Ohio. (Thesis, M. S., The Ohio State University) Columbus. 216 p.

SHEATSLEY, Larry Lee (1960) Pleistocene molluscan faunas of the Aultman deposit, Stark County, Ohio. (Thesis, M. S., The Ohio State University) Columbus. 161 p.

STURGEON, Myron Thomas (1933) The Stratigraphy and Paleontology of the middle portion of the Allegheny Formation of the Lisbon (Ohio) Quadrangle. (Thesis, M.A., The Ohio State University) Columbus. 91 p.

---- (1936) A contribution to the Allegheny Fauna of Eastern Ohio. (Thesis, Ph.D., The Ohio State University) Columbus. 174 p.

SZMUC, Eugene Joseph (1957) Stratigraphy and Paleontology of the Cuyahoga Formation of Northern Ohio. (Thesis, Ph.D., The Ohio State University) Columbus. 2 vols.

ZIMMERMAN, James Arthur (1958) Pleistocene molluscan faunas of the Newell Lake deposit, Logan County, Ohio (Thesis, M. S., The Ohio State University) Columbus. 156 p.

OREGON

ALLISON, Ira Shimmin (1966) Fossil Lake, Oregon: its geology and fossil faunas. (Oregon State Monographs. Studies in Geology, No. 9) Corvallis, Oregon State University Press. 48 p.

FREMONT, John Charles (1845) *(See citation under 'California')*

MOORE, Ellen James (1971) Fossil Mollusks of coastal Oregon. (Oregon State Monographs. Studies in Geology, No. 10) Corvallis, Oregon State University Press. 64 p.

TEXAS

ANDREWS, Jean (1971) Sea Shells of the Texas Coast. (The Elma Dill Russell Spencer Foundation Series, No. 5) Austin, University of Texas Press. 298 p.

GARDNER, Julia Anna (1935) The Midway Group of Texas. (The University of Texas Bulletin No. 3301, January 1, 1933) Austin, The University of Texas. 403 p.

NEWELL, Norman Dennis (1953) *(See citation under 'New Mexico')*

STEPHENSON, Lloyd William (1941) The larger invertebrate fossils of the Navarro Group of Texas (exclusive of corals and crustaceans and exclusive of the fauna of the Escondido Formation) (The University of Texas Publication No. 4101) Austin, The University of Texas. 641 p.

WENDORF, Fred, ed. (1961) *(see citation under 'New Mexico')*

WEST TEXAS GEOLOGICAL SOCIETY (1953) Stratigraphy of the Permian Basin of West Texas, with special reference to the cross sections of 1949, 1951, and 1953, by T. S. Jones, in cooperation with the Stratigraphic Problems Committee. Résumé of West Texas Permian Invertebrate fossils, by Harold L. Williams. n. p. 63 p.

UTAH

KATICH, Philip Joseph (1951) The Stratigraphy and Paleontology of the pre-Niobrara Upper Cretaceous rocks of Castle Valley, Utah. (Thesis Ph.D., The Ohio State University) Columbus, 208 p.

U. S. GEOLOGICAL AND GEOGRAPHICAL SURVEY OF THE TERRITORIES (1876) Report on the Geology of the eastern portion of the Uinta Mountains and a region of country adjacent thereto With atlas. By J. W. Powell. Washington, D. C. Gov't Ptg. Office. 218 p.

WASHINGTON

RICE, Thomas C. (1968) A checklist of the marine Gastropods from the Puget Sound Region; from the mouth of the Columbia River to the northern tip of Vancouver Island. Port Gamble, Wash., Of Sea and Shore. 169 p.

WISCONSIN

ROY, Edward Carl (1964) Pleistocene nonmarine Mollusca of Northeastern Wisconsin. (Thesis, Ph.D., The Ohio State University) Columbus. 156 p.

MIDDLE AMERICA

ANTILLES AND THE CARIBBEAN

WARMKE Germaine Le Clerc (1962) Caribbean Seashells; a guide to the marine mollusks of Puerto Rico and other West Indian islands, Bermuda and the Lower Florida Keys, by Germaine L. Warmke and R. Tucker Abbott. Narberth, Pa., Livingston. 348 p.

BERMUDA

WARMKE, Germaine Le Clerc (1962) *(See citation under 'Antilles and the Caribbean.')*

CUBA

MacGILLAVRY, Henry James (1937) Geology of the province of Camaguey, Cuba, with revisional studies in Rudist Paleontology (mainly based upon collections from Cuba) Utrecht, Holland, Printed by J. Van Boekhoven. 168 p.

MEXICO

ERBEN, Heinrich Karl (1954) Dos Amonitas nuevos y su importancia para la estratigrafía del Jurásico Inferior de México. (Paleontología mexicana No. 1) México D.F., Universidad Nacional Autónoma de México, Instituto de Geología. 23 p.

---- (1956) El Jurásico Inferior de México y sus Amonitas. (XX Congreso Geológico Internacional) México, D. F., Universidad Nacional Autónoma de México, Instituto de Geología. 393 p.

STREBEL, Hermann (1873) Beitrag zur Kenntniss der Fauna mexikanischer Land- und Süsswasser-Conchylien. (Abhandlungen aus dem Gebiete der Naturwissenschaften herausgegeben von dem Naturwissenschaftlichen Verein in Hamburg. Bd. 6. Hamburg, G. J. Herbst. 69 p.

PANAMA

OLSSON, Axel Adolf (1961) Mollusks of the tropical eastern Pacific, particularly from the southern half of the Panamic-Pacific faunal province (Panama to Peru); Panamic-Pacific Pelecypoda. New York, Paleontological Research Institution. 574 p.

PUERTO RICO

NEW YORK ACADEMY OF SCIENCES (1919-1942) Scientific Survey of Porto Rico and the Virgin Islands. New York, The Academy. 19 vols.

TRINIDAD

WALL, Georges Parkes (1860) Report on the Geology of Trinidad; or Part I. of the West Indian Survey. By G. P. Wall and J. G. Sawkins. London, Printed for H.M. Stat. Off. by Longman, Green, Longman and Roberts. 211 p.

VIRGIN ISLANDS

NEW YORK ACADEMY OF SCIENCES (1919-1942) *(See citation under 'Puerto Rico')*

SOUTH AMERICA
BRAZIL
HOLDHAUS, Karl (1918) Sobre alguns Lamellibranchios fosseis do Sul de Brasil. (Brazil. Serviço Geologico e Mineralogico. Monographias, v. 2) Rio de Janeiro, Imprensa Nacional. 32 p.
WHITE, Charles Abiathar (1888) Contributions to the Paleontology of Brazil; comprising descriptions of Cretaceous invertebrate fossils, mainly from the provinces of Sergipe, Pernambuco, Para and Bahia. Portuguese trans. by Orville A. Derby. (Extracted from vol. 7 of Archivos do Museu Nacional do Rio de Janeiro) Rio de Janeiro? 321 p.
CHILE
WETZEL, Walter (1930) Die Quiriquina-Schichten als Sediment und Paläontologisches Archiv. (Separat-Abdruck aus Palaeontographica, Bd. 73) Stuttgart, E. Schweitzerbart'sche Verlagsbuchhandlung. 106 p.
PERU
BOSWORTH, Thomas Owen (1922) Geology of the Tertiary and Quaternary periods in the north-west part of Peru. London, Macmillan. 434 p.

EUROPE (SPECIFIC REGIONS)
NORTH SEA
SCHÄFER, Wilhelm (1972) Ecology and paleoecology of marine environments; trans. from the German by Irmgard Oertel; edited by Y. Craig. (Trans. of Aktuo-Paläontologie nach Studien in der Nordsee) University of Chicago Press. 568 p.

EUROPE (COUNTRIES)
ARMENIA
ABICH, Hermann (1878-1887) Geologische Forschungen in den kaukasischen Ländern. Wien, in Commission bei A. Hölder. 3 vols.
AUSTRIA
LINZ, AUSTRIA. STADTMUSEUM (1969?) Geologie und Paläontologie des Linzer Raumes; der Boden von Linz. Katalog zu den Ausstellung des Stadtmuseums Linz in der Neuen Galerie der Stadt Linz, Wolfgang-Gurlitt-Museum und des Oö. Landesmuseums. (Its Kataloge zu Ausstellungen, 6; Kataloge des Oö. Landesmuseums, Nr. 64) Linz, Druck: Gutenberg Ges. 200 p.
SCHAFFER, Franz Xaver (1907-1908) Geologischer Führer für Exkursionen in inneralpinen Becken der nächsten Umgebung von Wien. Berlin, Gebrüder Borntraeger. 2 vols.
BELGIUM
MAILLIEUX, Eugène (1922) Terrains roches et fossiles de la Belgique. Bruxelles, Publié par les Naturalistes Belges. 164 p.
---- (1933) Terrains roches ... 2d ed., rev. et augm. Bruxelles, Patrimoine du Musée d'Histoire Naturelle de Belgique. 217 p.
MOURLON, Michel Félix (1880-1881) Géologie de la Belgique. Paris, Savy, Libraire de la Société Géologique de France. 2 vols. in 1.
BOHEMIA
BARRANDE, Joachim (1852-1911) Système silurien du centre de la Bohême. Partie: Recherches paléontologiques. Prague, l'auteur. 8 vols.
---- (1867) Céphalopodes siluriens de la Bohême. (Extrait du Système silurien du centre de la Bohême, vol. 2) Prague, l'auteur. 48 p.
---- (1867) Ptéropodes siluriens de la Bohême. (Extrait du Système silurien du centre de la Bohême, vol. 3) Prague, l'auteur. 16 p.
FRITSCH, Anton (1879) Fauna der Gaskohle und der Kalksteine der Permformation Böhmens, v. 1, pt. 1. Prague, in Commission bei F. Rivnáč.
BRITISH ISLES (IN GENERAL)
ARKELL, William Joscelyn (1933) The Jurassic System in Great Britain. Oxford, Clarendon Press. 682 p.
BEIRNE, Bryan P. (1952) The origin and history of the British Fauna. London, Methuen. 164 p.
BROWN, Thomas (1849) Illustrations of the fossil Conchology of Great Britain and Ireland, with descriptions and localities of all species. London, Smith, Elder. 173 p.
---- (1889) An Atlas of the Fossil Conchology of Great Britain and Ireland, with descriptions of all the species. London, S. Sonnenschein. 117 p.
BUCKMAN, Sydney Savory (1909-1912) Yorkshire type Ammonites. The original descriptions reprinted and illustrated by figures of the types, reproduced from photographs mainly by J. W. Tutcher. London, William Wesley. 1 vol.
FRETTER, Vera (1962) British Prosobranch Molluscs; their functional anatomy and ecology, by Vera Fretter and Alastair Graham. (Ray Society; sold by B. Quaritch. 755 p.
HARMER, Frederic William (1914-1920) The Pliocene Mollusca of Great Britain, being supplementary to S. V. Wood's Monograph of the Crag Mollusca. London, Printed for the Palaeontographical Society. 2 vols.
HIND, Wheelton (1896-1905) A Monograph of the British Carboniferous Lamellibranchiata. London, Printed for the Palaeontographical Society. 2 vols.
HUDLESTON, Wilfrid Hudleston (1887) British Jurassic Gasteropoda. London, Printed for the Palaeontographical Society. 1 vol.
LYCETT, John (1872-1879) A Monograph of the British fossil Trigoniae. London, Printed for the Palaeontographical Society. (Palaeontographical Society, London. Publications v. 26, 28, 29, 31, 33) London, Printed for the Palaeontographical Society. 5 vols.
---- (1881-1883) Supplement to a Monograph of the British fossil Trigoniae. (Palaeontographical Society, London. Publications v. 35, 37) London, Printed for the Palaeontographical Society. 2 vols.
MURCHISON, Roderick Impey (1872) Siluria. A History of the oldest rocks in the British Isles and other countries; with sketches of the origin and distribution of native gold, the general succession of geological formations,

and changes of the earth's surface. 5th ed. London, J. Murray. 566 p. Atlas (separate volume) has title: Figures of the Silurian fossils to illustrate Murchison's Siluria.

PALAEONTOGRAPHICAL SOCIETY, LONDON (1966) Directory of British fossiliferous localities. New York, Johnson Reprint Corp. 268 p.

PHILLIPS, John (1865-1909) A Monograph of British Belemnitidae: Jurassic. London, Printed for the Palaeontographical Society. 130 p.

SLATER, Ida L. (1907) A Monograph of British Conulariae. London. Printed for the Palaeontographical Society. 40 p.

SOWERBY, James (1812-1846) The Mineral Conchology of Great Britain; or, Coloured Figures and descriptions of those remains of testaceous animals or shells, which have been preserved at various times and depths in the earth. London, Printed by B. Meredith. 7 vols.

TRUEMAN, Arthur Elijah (1946-1947) A Monograph of British Carboniferous non-marine Lamellibranchia, by A. E. Trueman and J. Weir. London, Printed for the Palaeontographical Society. 3 vols. (Also issued as Palaeontographical Society, London. Monographs, v. 99, pt. 4

WEST, R. G. (1968) Pleistocene Geology and Biology, with especial reference to the British Isles. New York, Wiley. 377 p.

WOOD, Searles Valentine (1848-1882) A Monograph of the Crag Mollusca, with descriptions of shells from the Upper Tertiaries of the British Isles. London, Printed for the Palaeontographical Society, 4 vols. (Also issued as the Society's Monographs, v. 1, 4, 25, 27, 33, 36)

WRIGHT, Thomas (1878-1886) Monograph on the Lias Ammonites of the British Islands. London, Printed for the Palaeontographical Society. 503 p. (Also issued as the Society's Publications, v. 32, 33, 34, 36, 37, 38, 39)

ENGLAND

BLAKE, John Frederick (1905-1907) A Monograph of the Fauna of the Cornbrash. London, Printed for the Palaeontographical Society. 106 p.

DIXON, Frederick (1850) The Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex. London, Longman, Brown, Green and Longmans. 424 p.

EDWARDS, Frederic Erasmus (1849) A Monograph of the Eocene Cephalopoda and Univalves of England, vol. 1. By the late Frederic E. Edwards; continued by Searles V. Wood. London, Printed for the Palaeontographical Society. 361 p.

KENDALL, Francis (1816) A descriptive Catalogue of the minerals and fossil organic remains of Scarborough and the vicinity, including the line of coast from Hornsea to Mulgrave, and extending into the interior as far as Malton. Scarborough, T. Coultas. 316 p.

KING, William (1850) A Monograph of the Permian Fossils of England. London, Printed for the Palaeontographical Society. 258 p.

LYCETT, John (1863) Supplementary Monograph on the Mollusca from the Stonesfield Slate, Great Oolite, Forest Marble, and Cornbrash. London, Printed for the Palaeontographical Society. 129 p.

MANTELL, Gideon Algernon (1847) Geological excursions round the Isle of Wight, and along the adjacent coast of Dorsetshire; illustrative of the most interesting geological phenomena, and organic remains. London, H. G. Bohn. 428 p.

MORRIS, John (1854) A Monograph of the Mollusca from the Great Oolite chiefly from Minchinhampton and the coast of Yorkshire, by Professor Morris and John Lycett. London, Printed for the Palaeontographical Society. 2 vols. in 1.

MORTON, John (1712) The Natural History of Northamptonshire, with some account of the antiquities. London, Printed for R. Knaplock and R. Wilkin. 607 p.

PLOT, Robert (1677) The Natural History of Oxford-shire, being an essay toward the natural history of England. Oxford, Printed at the Theater. 358 p.

SHARPE, Daniel (1853-1909) Description of the fossil remains of Mollusca found in the Chalk of England. Cephalopoda. London, Printed for the Palaeontographical Society. 70 p.

SIMPSON, Martin (1942) The Fossils of the Yorkshire Lias; described from nature with a carefully measured section of the strata and the fossils peculiar to each. 3d ed. Hull, Eng., A. Brown. 256 p.

WHIDBORNE, George Ferris (1889-1907) A Monograph of the Devonian Fauna of the south of England. London, Printed for the Palaeontographical Society. 3 vols. (Also published in Palaeontographical Society's Publications, v. 42-47, 49, 50)

WOOD, Searles Valentine (1861-1871) A Monograph of the Eocene Bivalves of England, vol. 1. London, Printed for the Palaeontographical Society. 182 p.

---- (1877) Supplement. London, Printed for the Palaeontographical Society. 24 p. (Also published as the Society's Publication, v. 31)

WOODS, Henry (1899-1913) A Monograph of the Cretaceous Lamellibranchia of England. London, Printed for the Palaeontographical Society. 2 vols.

IRELAND

BROWN, Thomas (1849) *(See citation under 'British Isles')*

FOORD, Arthur Humphreys (1897-1903) Monograph of the Carboniferous Cephalopoda of Ireland. London, Printed for the Palaeontographical Society. 234 p.

WALES

WOBBER, Frank J. (1968) A Faunal Analysis of the Lias (Lower Jurassic) of South Wales, Great Britain. Bethesda, Md., International Business Machines Corp., Space Systems. 84 p.

FRANCE

BABIN, Claude (1966) Mollusques bivalves et céphalopodes du Paléozoïque armoricain. (Thèse, Rennes) Brest, Imprimerie Commerciale et Administrative. 470 p.

CUVILLIER, Jean (1961) Stratigraphic correlations by microfacies in Western Aquitaine. With the collaboration of V. Sacal. 3d ed. (International sedimentary petrographical series, v. 2) Leiden, E. J. Brill. 34 p.

FRANCE. SERVICE DES TOPOGRAPHIES SOUTERRAINES (1930-1951) Bassin houiller de la Sarre et de la Lorraine. (Études des gîtes minéraux de la France) Lille, Imprimerie L. Danel. 3 vols.

FURON, Raymond (1947) Catalogue des fossiles tertiaires du bassin de Paris, par Raymond Furon et Robert Soyer. (Savoir en histoire naturelle, v. 22; Guides techniques du naturaliste, v. 6) Paris, P. Lechevalier. 240 p.

GAUDRY, Albert (1873) Animaux fossiles du Mont Leberon (Vaucluse). Étude sur les vertébrés, par Albert Gaudry. Étude sur les invertébrés par P. Fischer et R. Tournouër. Paris, F. Savy. 180 p.

GUÉRIN-FRANIATTE, Simone (1966) Ammonites du Lias inférieur de France, Psiloceratacеae: Arietitidae. Paris, Centre National de la Recherche Scientifique. 2 vols.

HANCOCK, J.M. (1959) Les Ammonites du Cénomanien de la Sarthe. (Comptes rendus du Congrès des Sociétés Savantes, Dijon, 1959: Colloque sur le Crétacé supérieur français. Paris, Gauthier-Villars. p. 249-252

JULIEN, Alphonse (1896) Le terrain Carbonifère marin de la France centrale...avec coupes géologiques et dix-sept planches de fossiles. Paris, Masson. 304 p.

KILIAN, Wilfrid (1915) Contribution à l'étude des faunes Paléocrétacées du sud-est de la France. I. La faune de l'Aptien inférieur des environs de Montélimar (Drôme) (carrière de l'Homme d'Armes). II. Sur quelques Ammonites de l'Hauterivien de la Begude (Basses-Alpes) par W. Kilian....avec la collaboration de P. Reboul. (France. Service de la carte géologique de la France. Mémoires pour servir à l'explication de la carte géologique détaillée de la France) Paris, Imprimerie Nationale. 296 p.

---- (1920) Contributions à l'étude des céphalopodes Paléocrétacés du sud-est de la France. (Matériaux pour servir à la connaissance du Crétacé inférieur par MM. W. Kilian, M. Gignoux, E. Chaput, G. Sayn, P. Fallot et P. Reboul) (France. Service de la carte géologique de la France. Mémoires ....) Paris, Imprimerie Nationale. 266 p.

---- (1922) Contributions à l'étude des céphalopodes paléocrétacés du sud-est de la France. (Matériaux pour servir à la connaissance du Crétacé inférieur) Les *Spiticeras* du sud-est de la France, par M. A. Djanélidzé. (France. Service de la carte géologique de la France. Mémoires ....) Paris, Imprimerie Nationale. 207 p.

LOCARD, Arnould (1878) Description de la Faune de la Mollasse marine et d'eau douce du Lyonnais et du Dauphiné. (Extrait des Archives du Muséum d'Histoire Naturelle de Lyon, t. 2) Lyon, Pitrat Aîné. 278 p.

---- (1879) Description de la faune malacologique des terrains quaternaires des environs de Lyon. Lyon, H. George; Paris, J.-B. Baillière. 207 p.

VETTER, Pierre L. R. (1968) Géologie et Paléontologie des bassins houillers de Decazeville, de Figeac et du détroit de Rodez. Albi, Houillères du bassin d'Aquitaine. 2 vols.

GERMANY

GIEBEL, Christoph Gottfried Andreas (1852) Deutschlands Petrefacten; ein systematisches Verzeichniss aller in Deutschland und den angrenzenden Ländern vorkommenden Petrefacten nebst Angabe der Synonymen und Fundorte. Leipzig, A. Abel. 706 p.

HYATT, Alpheus (1880) The genesis of the Tertiary species of *Planorbis* at Steinheim. (Boston Society of Natural History. Anniversary Memoirs, 1880) Boston, The Society. 114 p.

KLOEDEN, Karl Friedrich von (1834) Die Versteinerungen der Mark Brandenburg, insonderheit diejenigen, welche sich in den Rollsteinen und Blöcken der sudbaltischen Ebene finden. Berlin, G. G. Lüderitz. 378 p.

KUHN, Oskar (1966) Die Tierwelt des Solnhofener Schiefers. 2., neu bearb. Aufl. (Die neue Brehm-Bücherei, 318) Wittenberg, Ziemsen. 40 p.

LEICH, Helmut (1968) Nach millionen Jahren ans Licht. Versteinerungen der Jurazeit. Thun, München, Ott. 164 p.

QUENSTEDT, Friedrich August von (1846) Petrefactenkunde Deutschlands. Abt. 1, Bd. 1: Cephalopoden. Tübingen, L. F. Fues. 581 p. (Atlas zu den Cephalopoden (separate vol.) 61 plates)

ROTHE, Hans Werner (1955) Die Ceratiten und die Ceratitenzonen des Oberen Muschelkalks (Trias) im Thüringer Becken. Frankfurt/M., Verlag Dr. Hans Werner Rothe. 69 p.

SALOMON-CALVI, Wilhelm (1966) Oberrheinischer Fossilkatalog Königstein-Taunus, Koeltz. 1 vol. (various pagings)

SCHMIDT, F.A. (1846) Petrefacten-Buch, oder allgemeine und besondere Versteinerungskunde, mit Berücksichtigung der Lagerungsverhältnisse, besonders in Deutschland. Stuttgart, Hoffman. 174 p.

GREECE

SCHNEIDER, Horst Ernst (1968) Zur quartärgeologischen Entwicklungsgeschichte Thessaliens (Griechenland). (Beiträge zur ur- und frühgeschichtlichen Archäologie des Mittelmeer-Kulturraumes, Bd. 6) Bonn, R. Habelt. 127 p.

HUNGARY

STRAUSZ, László (1966) Die Miozän-mediterranen Gastropoden Ungarns. Budapest, Akadémiai Kiadó. 692 p.

ITALY
BROCCHI, Giovanni Battista (1814) Conchiologia fossile subapennina, con osservazioni geologiche sugli Apennini e sul suolo adiacente. Milano, Stamperia Reale. 2 vols.
POLAND
FRIEDBERG, Wilhelm (1951-1954) Mięczaki mioceńskie ziem polskich i Krajów sąsiednich. (Poloniae finitarumque terrarum Mollusca Miocaenica) Krakow, Warszawa, Polskie Towarzystwo Geologiczne. 3 vols.
MAKOWSKI, Henryk (1962) Problem of sexual dimorphism in Ammonites. Zagadnienie dymorfizmu ptciowego u Amonitów. (Palaeontologia Polonica, No. 12) Warszawa, Pánstwowe Wydawnictwo Naukowe. 92 p.
PORTUGAL
DELGADO, Joaquim Filippe Nery da Encarnação (1908) Système Silurique du Portugal. Étude de stratigraphie paléontologique. Lisbonne, Imprimerie de l'Académie Royale des Sciences. 245 p.
ROMANIA
IONESI, Bica (1968) Stratigrafia depozitelor Miocene de platformă dintre valea Siretului şi valea Moldovei. Bucuresti, Editura Academiei Republicii Socialiste România. 391 p.
SWEDEN,
ISBERG, Orvar (1934) Studien über Lamellibranchiaten des Leptaenakalkes in Dalarna; Beitrag zu einer Orientierung über die Muschelfauna im Ordovicium und Silur. (Akademische Abhandlung—Uppsala) Lund, H. Ohlssons. 492 p.
SWITZERLAND
BUTIKOFER, Ernst (1920) Die Molluskenfauna des Schweizerischen Nationalparks. (Ergebnisse der wissenschaftlichen Untersuchung des Schweizerischen Nationalparks, 1; Denkschriften der Schweizerischen Naturforschenden Gesellschaft, Bd. 55) Zürich, Fretz. 132 p.
YUGOSLAVIA
BRUSINA, Spiridion (1866) Contribuzione pella Fauna dei Molluschi Dalmati. (Edito per cura dell'Imperiale e Reale Società Zoologico-Botanica di Vienna....) Vienna, A spese dell' I.R. Società Zoologico-Botanica. 134 p.

THE SOVIET UNION
RUSSIA
AKIMUSHKIN, Igor' Ivanovich (1965) Cephalopods of the Seas of the U.S.S.R. Trans. from Russian by A. Mercado; ed. by R. Finesilver. (At head of title: Akademiya Nauk SSSR. Institut Okeanologii. Academy of Sciences of the Seas of the U.S.S.R.) (TT 65-50013) Jerusalem, Israel Program for Scientific Translations; available from U.S. Dept. of Commerce, Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 223 p.
EICHWALD, Carl Eduard von (1852-1868) Lethaea Rossica; ou, Paléontologie de la Russie. Stuttgart, E. Schweizerbart. 3 vols. in 4. (vol. 1 - 1860)
KOROBKOV, I. A. (1955) Manuel et Guide des Mollusques Tertiaires: Gastéropodes. Trad.: Piétresson de St.-Aubin. Trans. from Russian. (Trad. No. 2944) Paris, Bureau de Recherches Géologiques et Minières, Service d'Information Géologique. 3 vols.
MURCHISON, Roderick Impey (1845) The Geology of Russia in Europe and the Ural Mountains. London, J. Murray. 2 vols.
SAKS, Vladimir Nikolaevich (1964-1966) Verkhneiurskie i nizhnemelovye Belemnity Severa SSSR. Leningrad, Nauka. 2 vols.
ZENKEVICH, Lev Aleksandrovich (1963) Biology of the Seas of the U.S.S.R. Trans. by S. Botcharskaya. New York, Interscience. 955 p.
SIBERIA
BALASHOV, Zakhar Grigor'evich (1962) Nautiloidei Ordovika Sibirskoĭ Platformy. Leningrad Gosudarstvennyĭ Universitet. 204 p.
TURKMENISTAN
AMANNIIAZOV, Kurban (1962) Stratigrafiia i Ammonity verkhneiurskikh otlozheniĭ Tuarkyra. Ashkhabad, Akademiia Nauk Turkmenskoi SSR. 170 p.

ASIA
KOBAYASHI, Teiichi, ed. (1964-) Geology and Paleontology of Southeast Asia. Tokyo, University of Tokyo Press. Vol. 1- (still not completed)
CEYLON
DERANIYAGALA, Paulus Edward Pieris (1958) The Pleistocene of Ceylon. (Ceylon National Museums. Natural History series) Ceylon, Printed at the Gov't Press. 164 p.
INDONESIA
WISSEMA, Gustaaf Gerard (1947) Young Tertiary and Quaternary Gastropoda from the Island of Nias (Malay Archipelago). Leiden, V/h L. H. Becherer. 212 p.
JAPAN
OYAMA, Katura (1960) Illustrated Handbook of Japanese Paleogene Molluscs, by Katura Oyama, Atsuyuki Mizuno and Toru Sakamoto. Tokyo, Geological Survey of Japan. 1 vol. (various pagings.
JAVA
MARTIN, Karl (1891-1906) Die Fossilien von Java; auf Grund einer Sammlung von R. D. M. Verbeek. (Sammlungen des Geologischen Reichs-Museums in Leiden, neue Folge, Bd. 1, Heft 1-10). Leiden, E.J. Brill. 10 vols. in 5
---- (1914-1915) Die Fauna des Obereocäns von Nanggulan auf Java. (Sammlungen des Geologischen Reichs-Museum in Leiden, neue Folge, Bd. 2, Heft 4-5) Leiden, E. J. Brill. 2 vols.
---- (1916-1917) Die Altmiocäne Fauna des West-Progogebirges auf Java. (Sammlungen des Geologischen Reichs-Museum in Leiden, neue Folge, Bd. 2, Heft 6-7) Leiden, E. J. Brill. 2 vols.
---- (1919) Unsere palaeozoologische Kenntnis von Java. (Beilage-Band zu Sammlungen des Geologischen-Mineralogischen Reichs-Museum in Leiden. E.J. Brill. 158 p.
MALAYA
MUIR-WOOD, Helen Marguerite (1948) Malay-

an Lower Carboniferous fossils and their bearing on the Visean Palaeogeography of Asia. London, British Museum. 118 p.

MONGOLIA

GRABAU, Amadeus William (1931) The Permian of Mongolia; a Report on the Permian Fauna of the Jisu Honguer Limestone of Mongolia and its relation to the Permian of other parts of the World. (Central Asiatic Expeditions of the American Museum of Natural History. Natural History of Central Asia, v. 4) New York, The American Museum of Natural History. 665 p.

SYRIA

GERMAIN, Louis (1921-1922) Mollusques terrestres et fluviatiles de Syrie. (At head of title: Voyage zoologique d'Henri Gadeau de Kerville en Syrie (avril-juin 1908) t. 2) Paris J.-Baillière. 2 vols.

HAMLIN, Charles Edward (1884) Results of an examination of Syrian molluscan fossils, chiefly from the range of Mount Lebanon. (Harvard College. Museum of Comparative Zoology. Memoirs, v. 10, no. 3) Cambridge, Printed for the Museum. 68 p.

AFRICA

GERMAIN, Louis (1920) Mollusques terrestres et fluviatiles (At head of title: Voyage de M. Guy Babault dans l'Afrique Orientale Anglaise; Résultats Scientifiques ... 1912-1913) Paris. Angers, Imprimerie F. Gaultier et A. Thébert.

---- (1923) Mollusques terrestres et fluviatiles. (At head of title: Voyage de M. Guy Babault dans l'Afrique Orientale Anglaise. Résultats scientifiques ... 1913) Paris, Blondel la Rougery. 148 p.

---- (1928) La Faune malacologique des hautes montagnes de l'Afrique Orientale. (Contribution à l'étude du peuplement des hautes montagnes, v. 2) Paris. Paul Lechevalier. 19 p.

----- (1932) Mollusques terrestres et fluviatiles. Recueillis par M. le Lieutenant Boëry à Oualata (Sahara Soudanais) (Extrait du Bulletin du Comité d'Études Historiques et Scientifiques de l'Afrique Occidentale Française, t. 14, No. 3, juillet-septembre 1931) Paris, Librairie Larose. 13 p.

NICKLÈS, Maurice (1950) Mollusques testacés marins de la côte occidentale d'Afrique. (Manuels Ouest-Africains, v.2) Paris, P. Lechevalier. 269 p.

SYMPOSIUM ON THE POST-CAMBRIAN SEDIMENTARY COASTAL BASINS OF WEST AFRICA, DELHI, 1964 (1966) Bassins sédimentaires du littoral africain, vol. 1. Paris, Association des Services Géologiques Africains. 304 p.

LIBYA

HAMMUDA, Omar Suleiman (1969) Jurassic and Lower Cretaceous rocks of Central Jabal Nefusa, Northwestern Libya. Tripoli, Petroleum Exploration Society of Libya. 74 p.

McBURNEY, Charles Brian Montagu (1955) Prehistory and Pleistocene Geology in Cyrenaican Libya; a record of two seasons' geological and archaeological field-work in the Gebel Akhdar Hills, with a summary of prehistoric finds from neighbouring territories, by C.B.M. McBurney and R. W. Hey. (Cambridge University. Museum of Archaeology and Ethnology. Occasional Publications, 4) Cambridge, Eng., University Press. 314 p.

MOROCCO

Paléontologie Marocaine (1947) Vol. 1: Généralités sur les invertébrés fossiles, par Geneviève Termier et Henri Termier. (Actualités Scientifiques et Industrielles, 1028) Paris, Hermann. (Also issued as Morocco. Service Géologique. Notes et Mémoires, No. 69, 1947, 391 p.)

MOZAMBIQUE

GERMAIN, Louis (1935) Contributions à l'étude de la Faune du Mozambique, Voyage de M. P. Lesne (1928-1929). 17e Note - Mollusques terrestres et fluviatiles. Coimbra, Coimbra Editora. 72 p.

TUNISIA

GERMAIN, Louis (1908) Étude sur les Mollusques recueillis par M. Henri Gadeau de Kerville pendant son voyage en Khroumirie (Tunisie) (Extrait du Voyage Zoologique en Khroumirie (Tunisie) par Henri Gadeau de Kerville, p. 129-296) Paris, J.-B. Baillière.

INDIAN OCEAN

MARION ISLAND

SOUTH AFRICAN BIOLOGICAL AND GEOLOGICAL EXPEDITION, 1965-1966 (1971) Marion and Prince Edward Islands; Report on the South African Biological and Geological Expedition, 1965-1966. Sponsored by the Department of Transport of the Republic of South Africa and supervised by the South African Scientific Committee for Antarctic Research. Edited by E. M. Van Zinderen Bakker, Sr., J. M. Winterbottom and R. A. Dyer. Cape Town, A. A. Balkema. 427 p.

MASCARENE ISLANDS

GERMAIN, Louis (1921) Faune malacologique terrestre et fluviatile des Iles Mascareignes. (At head of title: Mission zoologique de M. Paul Carie aux Iles Mascareignes.) Paris, Angers, Imprimerie F. Gaultier et A. Thébert. 495 p.

PRINCE EDWARD ISLAND

SOUTH AFRICAN BIOLOGICAL AND GEOLOGICAL EXPEDITION, 1965-1966 *(See citation under 'Marion Island')*

AUSTRALIA AND OCEANIA: AUSTRALIA

ALLAN, Joyce (1959) Australian Shells, with related animals living in the sea, in freshwater, and on the land. Rev. ed. (An Australiana Society Publication) Melbourne, Georgian House. 487 p.

LASERON, Charles Francis (1969) Ancient Australia; the story of its past geography and Life. Rev. by Rudolph Oskar Brunnschweiler. New York, Taplinger. 253 p.

Stratigraphy and Paleontology; essays in honour of Dorothy Hill (1969) Edited by K.S. W. Campbell. Canberra, Australian National University Press. 390 p.