SEASONAL SUCCESSION IN OLD FOREST PONDS.

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The phenomenon of seasonal variation in animal habitats has long been recognized, yet I have been unable to find any exact data on the subject in ecological literature. The investigations of which this is a preliminary report are being carried on with a view to help fill this deficiency. The results given are based on collections which have been made regularly since the summer of 1909.

DEFINITION.

Seasonal succession may be defined as the gradual replacing of one complex of animal life by another. These different complexes may be designated in terms of the species or taxonomic group of animals that are dominant at any given time. This dominance is composed of two factors: (1) pure numerical dominance, and (2) distribution in the pond. Either of these may vary without noticeably affecting the other. But since many of the forms never rise to a dominant position, seasonal succession requires a study of the seasonal development of each member of the complex.

This work on seasonal succession is important because of its bearing on ecological succession. The animal associations in one pond vary more at different times of the year than the associations of many ecologically related habitats studied at the same season. The seasonal changes have brought the same errors into the study of ecological succession that a disregard of daily migration would bring into work on seasonal succession.

AREA.

The ponds under consideration are in the oldest part of the slough system at the south end of Lake Michigan, where the subsidence of the lake has exposed a series of long sloughs and ridges. There are about one hundred of these between the lake and the last of the old Lake Chicago beaches. The ponds most carefully studied are in the ninety-third depression back from the lake. A part of this depression which has been isolated from the rest of the slough by artificial grades, has been the basis of most of the collections. In this pond the marginal areas are being invaded by bushes; the shallower part of the open water is overgrown by equisetum in the summer, and a smaller zone of lilypads occupies the deeper water.

Ecological conditions similar to the various habitats in Slough 93 were found in the fifty-sixth, ninety-second and ninety-fifth sloughs and a series of collections has been made in each of these. The plans for the work this spring include the making of a topographical map of this region. The mapping of the sloughs is to be based largely on new surveys made for that purpose.

QUALITATIVE SUCCESSION.

The first work attempted was to find the qualitative succession during the year. The results so far obtained are listed in Table I. Animals may have been present when they are not recorded in the list, but if they were, they must have been much restricted in numbers as well as in habitat.

TABLE I

GROUP NAME	SCIENTIFIC NAME.	Jan.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.
Agrionidæ larvæ	.....				*	*	*	*	*		
Agrionidæ adults	.....						*	*			
Backswimmers	Plea striola (Felt).....				*	*	*	*	*	*	
	Notonecta undulata (Say).....						*				
Branchipus	.....		*					*	*		
Caddice fly larvæ	.....										
Canthocampus	.....		*	*	*	*	*				
Chauliodes	Chauliodes rastricornis (Rambur)....		*				*	*			*
Chironomidæ larvæ	.....			*	*	*	*	*			
Cladocera	.....					*	*	*			
Crayfish	Cambarus immunis (Hagen).....		*	*	*	*	*	*	*	*	*
Cyclops	.....		*	*	*	*	*	*			
Diaptomus	.....		*				*	*	*	*	
Diptera	Corethra larvæ.....		*				*	*			
	Stratiomyiidæ							*			
Donacia sp.	.....							*			
Dragonflies	Anax junius (Drury).....						*	*			
	Libellula pulchella (Drury).....						*	*			
	Lestes vigilax (Hagen).....						*	*			
	Lestes rectangularis (Say).....						*	*			
	Sympetrum obtrusum (Hagen)....						*	*			
	Sympetrum rubicundulum (Say)....						*				
	Aeschnidæ larvæ.....					*		*			
	Libellulidæ larvæ.....			*	*	*				*	
Dytiscidæ	Ilybius sp.....			*	*	*	*	*	*	*	*
	Hydroporus modestus (Aube).....			*	*	*	*	*	*	*	*
	Desmopachria convexa (Aube).....						*	*			
	Colymbetes sculptilis (Harr.).....						*	*			
	Laccophilus sp.....						*	*			
	Graphoderes sp.....						*	*			
	Larvæ sp.....					*	*	*			
Ephemeridæ	Siphlurus sp.....			*	*	*		*			
Flatworms	.....		*	*			*	*		*	
Frog	Rana sp. adult.....		*				*	*	*		
	Rana sp. larvæ.....		*				*	*	*		
	Acris gryllus (Le Carte).....							*			
Gammaridæ	Eucrangonyx gracilis (Smith).....	*	*	*	*	*	*	*	*	*	*
Giant water bug	Amorgius americanum (Leidy).....					*	*	*	*		*
Gyrinidæ	Dinentes hornii (Roberts).....			*	*	*	*	*			
Heterotrichidæ	.....						*				
Hydrophyllidæ	Berosus sp.....					?	*		*	*	*
	Larvæ								*	*	*
Isopoda	Asellus communis (Say).....	*	*	*	*	*	*	*	*	*	*
	Mancasellus danielsii (Richardson)...		*	*	*	*	*	*	*	*	*
Leech	Erpobdella punctata (Leidy).....		*	*		*	*	*	*		*
	Glossiphonia heteroclita (Lin.).....						*				
Lymnæidæ	Lymnæa reflexa (Say).....			*	*	*	*	*	*	*	
	Planorbis exacutus (Say).....				*	*	*	*	*	*	
	Planorbis trivolvis (Say).....		*	*	*	*	*	*	*	*	*
	Planorbis deflectus (Say).....				*	*	*				
	Segmentina armigera (Say).....		*	*	*	*	*	*	*	*	*

Microdrilæ	.....					*					
Mollusca	Ancylus tardus (Say).....					*	*				
Mosquito	Culex sp. adult.....				*	*	*				
	Culex sp. larvæ.....				*	*	*				
Oligochaetæ	.....				*	*					
Ostracoda	.....			*	*	*	*				
Paramœcium	.....					*	*				
Physidæ	Physa gyrina (Say).....		*	*	*	*	*	*	*	*	*
Hydrochinidæ	.....			*	*	*	*	*	*	*	
Salamander	Amblystoma tigrinum (Green).....						*				
Sphæridæ	Musculium securis (Prime).....					*	*				
	Musculium truncatum (Lins.).....		?	?	?	?	*	*	*	*	*
Spiders	Pilæus militaris (Hentz).....						*	*			
	Chibonia sp.....	?	?				*	*			
Sponge	Spongilla fragilis (Leidy).....	*	*	*	*	*	*	*	*	*	*
Thysanura	.....	*	*	*	*	*	*	*			
Vorticelli	.....						*				
Water boatmen	Corixa sp.....					*	*	*	*		
Water striders	Gerris marginatus (Say).....		*			*	*	*	*	*	
Water scorpion	Ranatra fusca (P. B.).....					*	*	*			
	Hydrometri martini (Kirk).....						*	*			
Zaitha	.....					*	*	*			
	Totals	5	24	23	25	40	56	64	25	19	15

As would be expected, the number of species present is greatest in mid-summer. The culmination in number of forms living in the water comes in July. The greatest invasion of land forms into the pond area occurs in August when the water level is low and the pond is more nearly choked with vegetation.

QUANTITATIVE SUCCESSION.

Qualitative work, however, is not sufficient ground on which to base exact conclusions. It is also necessary to have exact data regarding the abundance of each of these species throughout the year. In order to obtain this information quantitative collections must be taken. The quantitative work carried on so far has been done by means of nets of a known size operated through like distances in as nearly like conditions as possible. It may be added that in order to do away with the obvious sources of error arising from collecting with nets, a galvanized iron cylinder should be used. This should be sunk into the mud for each collection and the animals contained in it counted and their position noted.

Table II shows the results of quantitative tow-net collections made at the surface of the lilypad region. In these the net used was of millers' bolting cloth, with an opening one foot in diameter. The net was slowly hauled a distance of forty feet with the top of the opening at the water's surface. The collections were made in the early morning or late afternoon to guard against errors due to the daily vertical migration, which was very pronounced. In all instances the figures show the result of one typical haul taken near the close of the month. Unfortunately, the collections for July were made under too diverse conditions to be comparable to

those of the other months. Only some of the most typical species are listed.

TABLE II.

QUANTITATIVE SURFACE COLLECTIONS.

GROUP NAME.	SCIENTIFIC NAME.	March.	April.	May	June.	August.	Sept.	Oct.
Snail	Lymnaea reflexa (Say).....		1	3	23	78	15	1
	Planorbis exacutus (Say).....			3	10	1	1	1
	Physa gyrina (Say).....	1	1		12		1	1
	Segmentina armigera (Say)...		1		10	4		
	Planorbis trivolvis (Say).....					9		
Sphaeridæ	Musculium truncatum (Lins.).			2	1		3	
Isopoda	Asellus communis (Say).....		3	30	25	2		
	Mancasellus danielsii (Richardson)	3	3	1		1	2	1
Amphipoda	Eucrangonyx gracilis (Smith)	3	4	1	8		2	
Branchipus	.....	6						
Ephemeridæ larvæ	.....			2	20			
Agrionidæ larvæ	.....			11	1			
Corethra larvæ	.....	2				1	1	
Hydrochinidæ	.....			4		1	1	1
Dytiscidæ	Dytiscus sp.		2	1	5	2	3	1

The table shows that the number of individuals present at the surface increases and decreases in much the same manner as the number of species. This is best shown by the snail *Lymnaea reflexa,* whose relative abundance gives data for an almost perfect seasonal curve. Pronounced cases of seasonal change due directly to breeding habits are shown by the *Ephemeridæ* and *Agrionidæ* larvæ.

In midsummer this lilypad region was the most thickly populated of any part of the pond, but earlier in the spring animals had been most abundant at the bottom along the pond margin. Table III shows the results of dredgings made at the margin during this season of marginal dominance. These collections were made with a dip net one foot in diameter, with all variable features made as comparable as possible. Each number is the result obtained from three consecutive dredgings.

TABLE III.

QUANTITATIVE BOTTOM COLLECTIONS.

GROUP NAME.	SCIENTIFIC NAME.	April.	May.	June.
Snails	Planorbis trivolvis (Say).....		5	
	Planorbis deflectus (Say).....		5	
	Segmentina armigera (Say).....	3	11	
	Physa gyrina (Say).....			1
Sphariidæ	Musculium truncatum (Lins.).....		7	8
Isopoda	Asellus communis (Say).....	54	48	57
	Mancasellus danielsii (Richardson).	20	13	1
Amphipoda	Eucrangonyx gracilis (Smith).....	49	62	4
Dytiscidæ	Dytiscus sp.	1	1	
Leech	Erpobdella sp.	1	1	
Hydrophyllidæ larvæ	.....			1

The figures show the decrease of the crustacean complex in this region and a start toward the summer increase among the molluscs. They also show that the margin does not lose its ascendency so much on account of a mid-summer decrease in the forms present in this part of the pond, but rather because of the amount of animal life among the lilypads.

The same state of affairs is shown by the relation between the pond crustaceans and the pond snails. The crustaceans remain near the same number throughout the year, while the snails are represented by only a few forms in the spring and autumn, but are more abundant than any other group in mid-summer. This makes the crustaceans the dominant group in spring and autumn, not

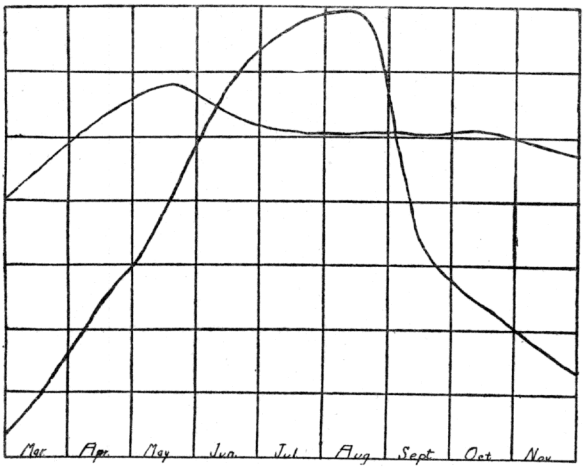

Figure 5. Variation curves of pond snails and crustaceans.

because of any decided difference in their own numbers, but because of the scarcity of the snails. The relation existing between the two forms throughout the year is illustrated by the curves plotted in Figure 5. The longer curve represents the seasonal development of the molluscan group. The strong increase in the spring is due at first to their coming out of hibernation and later to the progress of the new generation. The rapid decrease is due both to death and to hibernation. With the *Isopods* the breeding season culminates much earlier and the old generation tends to die off, leaving a fairly constant midsummer line. Both com-

plexes end higher in the autumn than they start in the spring—a condition which must be due to the effect of winter killing.

SUMMARY.

The results so far obtained in this investigation may be briefly summarized as follows:

(1) The phenomena of seasonal succession holds, both in regard to succession of species and to the number of individuals in a species.

(2) The position of dominance in point of numbers and of distribution is held by crustaceans in the spring and autumn, with *Asellus communis* as the dominant species; and by molluscs in midsummer, with *Lymnaea reflexa* dominant.

(3) The most crowded habitat is on the bottom along the pond margin in spring, on the surface or in the mid-depths of the deepest water in midsummer, and near the green water plants in autumn.

(4) The forms tend to distribute themselves over the whole pond, but are much more restricted during part of the year, especially during the breeding season.

The external factors influencing seasonal succession may be summarized as: temperature, amount of water, chemical composition of water, amount and character of food and the physical condition of the habitat. In seasonal succession the dynamic effect of the animals themselves upon their own habitat is not nearly so marked as in ecological succession; yet this dynamic effect can be demonstrated to be present so that the phenomena of seasonal succession may be regarded as the cyclic or slightly spiral process, by means of which ecological succession is carried on. It therefore presents a minute unit for the study of the general succession problem. While no attempt has been made as yet to analyze the causes of seasonal succession into their ultimate factors, still, by careful quantitative collecting of animals and by complete chemical analysis of the pond water we may hope to find these factors. At least we can approximate them with much more certainty than in ecological succession, where the time element presents a great complication.

The writer is indebted to Dr. V. E. Shelford for help and kindly criticism during the continuance of this work.