Ducks and Shellfish Sanitation*

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IT has generally been accepted in the past, that pollution of animal origin was not so potentially dangerous as pollution of human origin. Recent studies of the relation of pathogenic to coliform organisms in duck polluted waters would seem to require some revision in this concept. These studies reported for the first time in this paper, indicate that duck pollution is a very definite public health factor in shellfish sanitation.

The chief problems of shellfish sanitation consist of: (1) The determination of safe production areas from which shellfish may be taken for food without danger to the public health; (2) the inspection of plants opening and packing shellfish to assure the continued safety of the product being shipped. The investigations reported herein deal entirely with the first of these problems, and the studies made in one of the many areas of Long Island for the purpose of deciding its potential safety as a source of production. This area is at the easterly end of Long Island and is known as the Peconic River, Reeves Bay, and Flanders Bay area. It consists of some 3,500 acres from which some oysters and large quantities of hard clams are produced annually.

The two main factors considered in a study of this type are: (1) the sanitary survey of the watershed, (2) the results of laboratory examination of samples of water for the presence of pollution organisms.

THE SANITARY SURVEY

The Peconic River is about 12 miles long with approximately 40 square miles of watershed. The average daily run-off of fresh water from the watershed is estimated at 40 m.g.d. The watershed is sparsely settled and is mostly farm and woodlands. The river is a fresh water stream above the village of Riverhead. Below Riverhead for about 2 miles it is a tidal estuary finally discharging into Flanders Bay. Flanders Bay and Reeves Bay and the tidal estuaries tributary thereto are subjected twice a day to the influence of some 4,500 m.g. of clean salt water due to the rise and fall of about 4 feet of tide entering the bays from the east.

The tidal areas are subjected to a few minor sources of human pollution in and around Riverhead. The village of Riverhead has a public sewerage system and treatment plant and discharges effluent about halfway between the village and the mouth of the river. The treatment plant was placed in operation in 1938. It is an activated sludge plant of modern design and adequate capacity. Samples collected at various times indicate that it is well operated. Typical results of operation indicate 96 per cent removal of the suspended solids (raw 616 p.p.m.) 90 per cent removal of B.O.D. (raw 500 p.p.m.) and effective

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chlorination, the effluent showing a maximum MPN per 100 ml. of 330.

The river also receives the untreated wastes from a laundry at Riverhead. The discharge of these wastes may have some slight effect on the river, but serious damage from this source has not been demonstrated by laboratory results. Sources of human or industrial pollution in this entire drainage area, therefore, are considered to be insignificant.

The greatest source of pollution in this area, is the numerous duck farms located at various points along the river and near its entrance to the bay. These ducks are of the White Pekin variety and are grown in large numbers during the spring, summer and early fall. Only a relatively few ducks are kept on the farms for breeding purposes during the winter months. A survey of duck farms made in 1937 indicated some 21 farms in this area producing more than one million ducks annually. Production has increased considerably since that time and it is estimated that some two million are now grown annually.

Years ago, the duck pens extended directly into the tidal streams. Duck diseases were transmitted from one farm to another to a serious extent under these conditions. In recent years, in order to isolate individual farms and eliminate the spread of disease from one farm to another, most of the farms now have separated their pens from the main streams by the building of dikes. The water in the duck pens is usually obtained by pumping from wells. The overflow from the pens, however, is discharged into the streams. The quantity of water flowing from the pens may vary considerably due to tidal actions, rainfall, etc. On one medium size farm the average discharge appears to be in the neighborhood of some 500 to 900 g.p.m.

The character of the water discharged from the pens also varies considerably depending upon rainfall, the number of ducks in the pens, and their activities. Analysis of the overflow from these farms indicates suspended solids varying from 80 p.p.m. to more than 1,800 p.p.m. and B.O.D. values of from 60 p.p.m. to 380 p.p.m. Coliform organisms are present in the order of a MPN of 10,000,000 or more per 100 ml. It would appear that near the mouth of the Peconic River, during the summertime, the waters receive duck farm wastes equivalent to the discharge of raw sewage from a village of more than 20,000 persons.

LABORATORY RESULTS

Samples of water have been collected from this area many times and under various conditions since 1937. Fourteen separate surveys have been made during these studies. It is the usual procedure to collect one sample at each quarter stage of the tide, making a total of four samples at each sampling station. These are examined for coliform organisms and total bacteria.

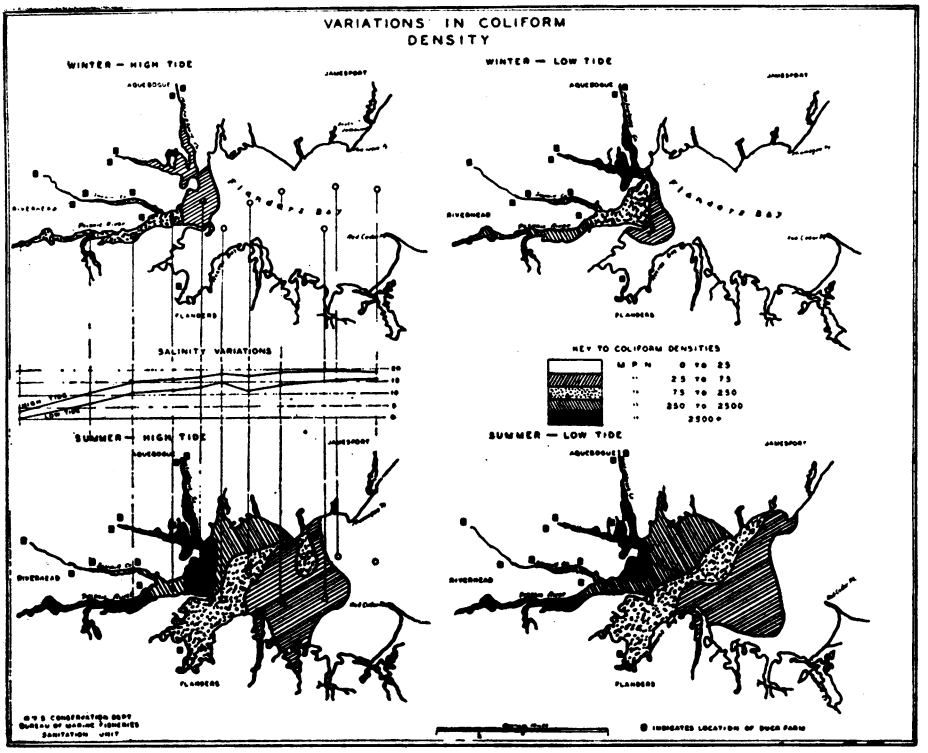
Chart 1 shows the seasonal and tidal variations in coliform densities throughout this area and is based on the composite results of samples collected over a 12 year period. The vast extent of polluted waters during the summer months is evident from this chart and is considered to be the direct result of the increased duck population during this period.

This chart also shows typical salinity variations at high and low tide throughout this area starting with fresh water at Riverhead and approaching seawater conditions near the middle of the bay. The locations of the various duck farms are also shown.

INTERPRETATION OF THE DATA

It has been shown that this shellfish area contains excessive numbers of coliform organisms during the summer months and that these coliforms are of animal rather than human origin. If the coliforms found in this area were of

CHART 1



human origin then a pathogen coliform ratio would be expected to exist. In this case the pathogens would be assumed to be of the typhoid group and would be present in sufficient numbers to constitute a definite menace to the public health. This would warrant closing this area to the taking of shellfish. However, the coliforms present are definitely known to be of animal rather than human origin, originating from the duck population; therefore, the public health significance of these coliforms becomes questionable unless it can be demonstrated that a similar pathogen coliform ratio exists. If such a relationship can be demonstrated, then the presence of these coliforms—i.e., of duck origin—also indicates a definite public health menace. Under such circumstances it becomes necessary to close the area to the taking of shellfish.

PATHOGENS PRESENT IN DUCK WASTES

The literature is quite extensive on the presence of members of the *Salmonella* group in ducks and duck droppings. Edwards[1] reports on 56 outbreaks of salmonellosis in ducks, from which 13 types were isolated. All of these types are recorded by Seligman[2] and Edwards,[3] as having been associated with outbreaks of salmonellosis in humans.

Pathogenicity of *Salmonella* from ducks is more directly demonstrated by Mallam,[4] Scott,[5] and Snapper,[6] who cite cases of human salmonellosis resulting from the ingestion of duck eggs or food prepared from them.

Of particular significance from the standpoint of pollution is the method of infection of these eggs. Both Mallam and Scott agree that the eggs become infected either by introduction of con-

TABLE 1

Incidence of Salmonella Types Isolated in Infections of Man and Ducks

Type	Man Edwards [1] No. Outbreaks	Man Edwards [1] No. Cases	Man Edwards [1] No. Fatalities	Man Seligman [2] No. Outbreaks	Man Seligman [2] No. Cases	Man Seligman [2] No. Fatalities	Ducks Edwards [3] No. Outbreaks
Total—All Types	1677	2949	56	941	1107	57	56
S. Typhi-murium	357	469	12	307	356	22	32
S. derby	49	126	1	34	37	1	1
S. bredeny	16	34	0	4	4	0	2
S. panama	73	124	4	46	57	1	1
S. give	36	75	0	17	17	0	2
S. anatum	64	165	1	49	64	1	8
S. meleagridis	16	43	0	13	13	0	0

TABLE 2

Isolations of Salmonella from Duck Farms and Tributary Waters

Date	Station	Coliform MPN/100 ml.	Salmonella Isolated	Volume of Sample tested—ml.
5/10/49	Farm A	9,300,000	*S. anatum, S. typhi-murium*	10
	Farm B	9,300,000	*S. meleagridis, S. bredeny*	100 & 10
	Farm C	930,000	*S. typhi-murium*	10
	Farm D	15,000,000	*S. typhi-murium*	10
	Farm E	2,400,000	none isolated	100 & 10
Meetinghouse Creek				
8/2/48	Sta. 5.1	4,600,000	*S. bredeny, S. give*	10
6/8/48	Sta. 5.2	2,400,000	*S. bredeny*	10
6/13/48	Sta. 5.2	930,000	*S. bredeny*	100
8/2/48	Sta. 5.2	4,600,000	*S. bredeny*	10
9/27/48	Sta. 5.2	2,400,000	*S. bredeny*	10
7/12/48	Sta. 5.2A	930,000	*S. typhi-murium, S. bredeny*	10
Sawmill Creek				
9/27/48	Sta. 7.2	11,000,000	*S. typhi-murium*	10
	Sta. 7.1	460,000	*S. typhi-murium*	10
Flanders Bay				
7/12/48	*Water* Sta. 4.1	4,600	none isolated	100 & 10
7/12/48	*Oysters* Sta. 4.1	24,000+	*S. typhi-murium*	10
9/27/48	*Water* Sta. 4.1	3.6	none isolated	100 & 10
9/27/48	*Oysters* Sta. 4.1	330	none isolated	100 & 10

taminated material into the oviduct during copulation, or by direct contact of the egg with contaminated fecal material on the ground. Thus, the prime origin of *Salmonella* in eggs is *fecal material.* These observations are also confirmed by Solowey,[7] who found that eggs with adhering fecal material were infected with *Salmonella* more often than clean eggs. The infection could not be attributed to contamination during the opening since pre-washing in heavily chlorinated water, or wet or dry scrubbing did not reduce the incidence of infected eggs.

Hilbert[8] reports occasional *S. anatum* infections among Long Island ducks; Hansen[9] reports *Salmonella* infections as great as 5 per cent in European ducks; and Clarenberg[10] reports at least 1 per cent infections among ducks in other parts of this country. These reports indicate that it is quite common for flocks of ducks to be heavily infected with *Salmonella* and that they should be included in the statement of Edwards[1] that "birds constitute the greatest reservoir of paratyphoid infection among domestic animals."

In order to demonstrate the presence of pathogens in the wastes from the Long Island duck farms and to show

the possibility of the transmission of these pathogens from the farms through the shellfish waters and actually to the shellfish, special samples were collected and examined for the coliform and *Salmonella* groups. The results obtained appear in Table 2.

These special samples were collected principally from Meetinghouse Creek and Saw Mill Creek for three reasons; (1) because of the absence of any significant amount of human pollution; (2) because of the presence of a great amount of duck pollution; and (3) because of the nearness of these creeks to productive shellfish grounds.

It will be noted from Table 2 that viable pathogenic types of *Salmonella* were isolated from the discharges of duck farms and the waters immediately adjacent to these farms. It was also possible to recover *Salmonella* at least ¼ mile away from the nearest duck farm. Perhaps the most significant result in this table is the recovery of one type of *Salmonella* from a sample of oysters taken from a private oyster bed in Flanders Bay, which, during the winter months is considered to be of satisfactory sanitary quality.

These results appear to establish beyond any doubt a definite relationship of pathogens to coliforms when the source of such coliforms is of duck origin. Therefore, the presence of excessive coliform organisms of duck farm origin must be considered as a public health menace and areas polluted by duck farms must be closed to the taking of shellfish following the same administrative procedures that are used when the source of such coliform is of human origin.

ABATEMENT OF POLLUTION BY DUCK FARMS

It has been mentioned previously, that in order to control diseases, the modern duck farmer has isolated his farm from the adjacent stream by means of dikes and has supplied the duck pens with clean, fresh water, usually obtained from driven wells or upland reservoirs. The water flows from pen to pen and finally discharges through an opening in the dike, usually a tide gate. Thus, the first stage of abatement, namely isolation and consolidation of the wastes, has been accomplished on the modern farm.

Field and laboratory experiments have been conducted at one such farm to determine the characteristics of the wastes with a view to applying the principles of domestic sewage treatment. These experiments have indicated that the solids are rapid settling, the greatest part of the settleable solids being removed within 5 to 30 minutes.

Field experiments indicate the feasibility of plain settling followed by chlorination as the method of treatment of these wastes. The experiments demonstrated that from 50 per cent to 93 per cent of the suspended solids could be removed in one hour's detention. The effluent then was in satisfactory condition for chlorination. In one experiment, the coliform MPN of the effluent was reduced from 46,000,000 to 430 by the application of 10 p.p.m. of chlorine, leaving a residual of 0.7 p.p.m. after 15 minutes contact.

CONCLUSIONS

In conclusion, it appears from the studies made of duck farm pollution of shellfish areas that:

1. Pathogenic organisms are present in the wastes discharged or flowing from duck farms.
2. Such organisms—potentially dangerous to man—have been recovered in shellfish taken from water polluted by duck farms.
3. Public health agencies in charge of shellfish sanitation must give due consideration to the presence of excessive numbers of coliform organisms originating from duck farms.
4. The elimination of this pollution by

reasonable and economical means appears possible and is necessary in the public interest.

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New Isotope Laboratory

The National Institutes of Health of the U. S. Public Health Service has established an Isotope Laboratory for research involving radioisotopes, one of the few radioisotope laboratories in America designed solely for medical research. The Laboratory is prepared for immediate experimentation in a wide variety of fields. Among the projects under way are:

1. A study with radioactive iodine to determine how the thyroid gland function depends on dietary intake for both normal and thyroid tumor tissue.
2. A study on the biological effects of alpha particles from radon, and a comparison of these effects with other types of radiation, especially x-rays.
3. A study with radioactive phosphorus involving the metabolism of various phosphorus compounds.
4. A study with carbon-14 to determine the distribution of chemotherapeutic agents thought to have value in the treatment of cancer.