Progress Notes

Aussi disponible en français

No. 105, December 1979

Canadian Wildlife Service

Progress Notes contain *interim* data and conclusions and are presented as a service to other wildlife biologists and agencies.

Second tour of inspection of Quebec heronries, 1978

by J.-L. DesGranges[1] and P. Laporte[1]

Abstract
During this second tour of inspection, 34 Quebec heronries were visited and their nests counted. Twenty-four of these colonies had previously been the subject of a similar inventory. As in the first tour, we found that the number of platforms and occupied nests had declined in almost two-thirds of the heronries inspected. Appreciable population increases in a few colonies, however, offset losses elsewhere and showed a net gain for the survey as a whole. The average number of eggs laid per nest in the St. Lawrence estuary was 4.0 ($S_{\overline{X}}$ = 0.20). The average number of young herons produced per successful brood in a colony was approximately 2.24 ($S_{\overline{X}}$ = 0.60) in 1978, compared to 2.13 ($S_{\overline{X}}$ = 0.55) for the heronries inspected in 1977. The thinning eggshell syndrome does not appear to be a significant problem among Great Blue Herons in Quebec. In some areas, however, a shortage of food may have led to a substantial reduction in brood size.

Introduction

Inspection tours of Quebec heronries started in 1977 (DesGranges, *et al.* 1979). Professional ornithologists and volunteers work together in this collective effort which is co-ordinated by the Quebec office of CWS. This 10-year study should enable us to better monitor the fluctuations in Great Blue Heron populations in Quebec and measure the degree to which heron eggs are contaminated by toxic substances in the environment. We hope this study will enable us to detect possible changes caused by pollution due to man or through changes in the environment, so that corrective measures may be taken in time.

This report concerns the changes which have occured within Quebec heronries from 1977 to 1978.

Methodology

Data collection methods are approximately the same as in 1977 (see description in DesGranges *et al.* 1979). Some procedures were revised in 1978, however, to allow a larger number of helpers to participate in this second tour of inspection. The inventory method devised for the first tour of inspection called for two visits to each heronry during the course of the summer: around the third week in May, after the egg-laying, and in early July, about 2 weeks before the young herons leave the nests. Many of our helpers were unable to make both visits due to lack of time. Nevertheless, we have retained the data collected during these single visits and will ask participants in future to make only one visit to the colonies in early July. At that time the occupied and vacant nests, in fact, may be more readily distinguished: active nests then are whitened by excrement and often contain young, while vacant nests are almost unstained and are often dilapidated, much of their material having been used to mend active nests within the colony. Finally, eggshell fragments may still be collected beneath nests at this stage of the summer.

By eliminating the May visit, however, we lose the opportunity to collect some fresh eggs for contaminant analysis. This drawback is nevertheless not a major one, since very few of our helpers are capable of climbing a tree to collect an egg from a nest. We plan to make up for this deficiency by setting up a mobile team specialized in the collection of fresh eggs; during its May visit to several heronries, this team will also collect ecological data as has been done formerly at the "first visit".

Contrary to what we thought at the start of the study, active nests are more difficult to identify during the first visit than during the second. At the end of May, the use of some nests has often been too short to permit a reliable diagnosis. Moreover, this visit during the incubation period sometimes causes desertion of some nests, to such an extent that the data collected at that time are not readily comparable to those obtained during the second visit. Hence, we feel it clearly indicated that we should eliminate this general visit in May, since almost all of the necessary data can be collected in July. Moreover, the latter visit is less harmful to the birds because the nesting period is more advanced and there is less risk of adults abandoning their nest, since by that time they are much more concerned with the success of their brood.

Results

Highlights of the tour

We visited 34 heronries in 1978, four less than in 1977 (Fig. 1, Table 1). Among those, 24 had been inspected in 1977, while one other had been last inventoried in 1971. As in 1977, the largest numbers of heronries inspected were in the Outaouais region and the St. Lawrence estuary. This year, for the first time, our tour included heronries in northwestern Quebec and along the North Shore. Thirty-seven helpers joined in the second tour of inspection, whereas only 14 persons had been involved in the first tour.

Additions to and deletions from the the list of Quebec heronries

In 1978, the list of known heronries in Quebec was increased by nine (Table 1) to raise their current total to 120 (DesGranges, in prep.). Among these additions, only the colonies located at Battures aux Loups Marins and on Île du Pot à l'Eau-de-Vie in the St. Lawrence estuary were probably established in 1978. In fact, when we flew over these two sites during the summer of 1977 we saw no heronries. We doubt that these two heronries existed before 1977, since Reed (1973) makes no mention of them in his work on bird colonies of the St. Lawrence estuary, and because several biologists have visited these sites during the past decade without discovering a heronry.

[1]CWS, Quebec G1V 4H5

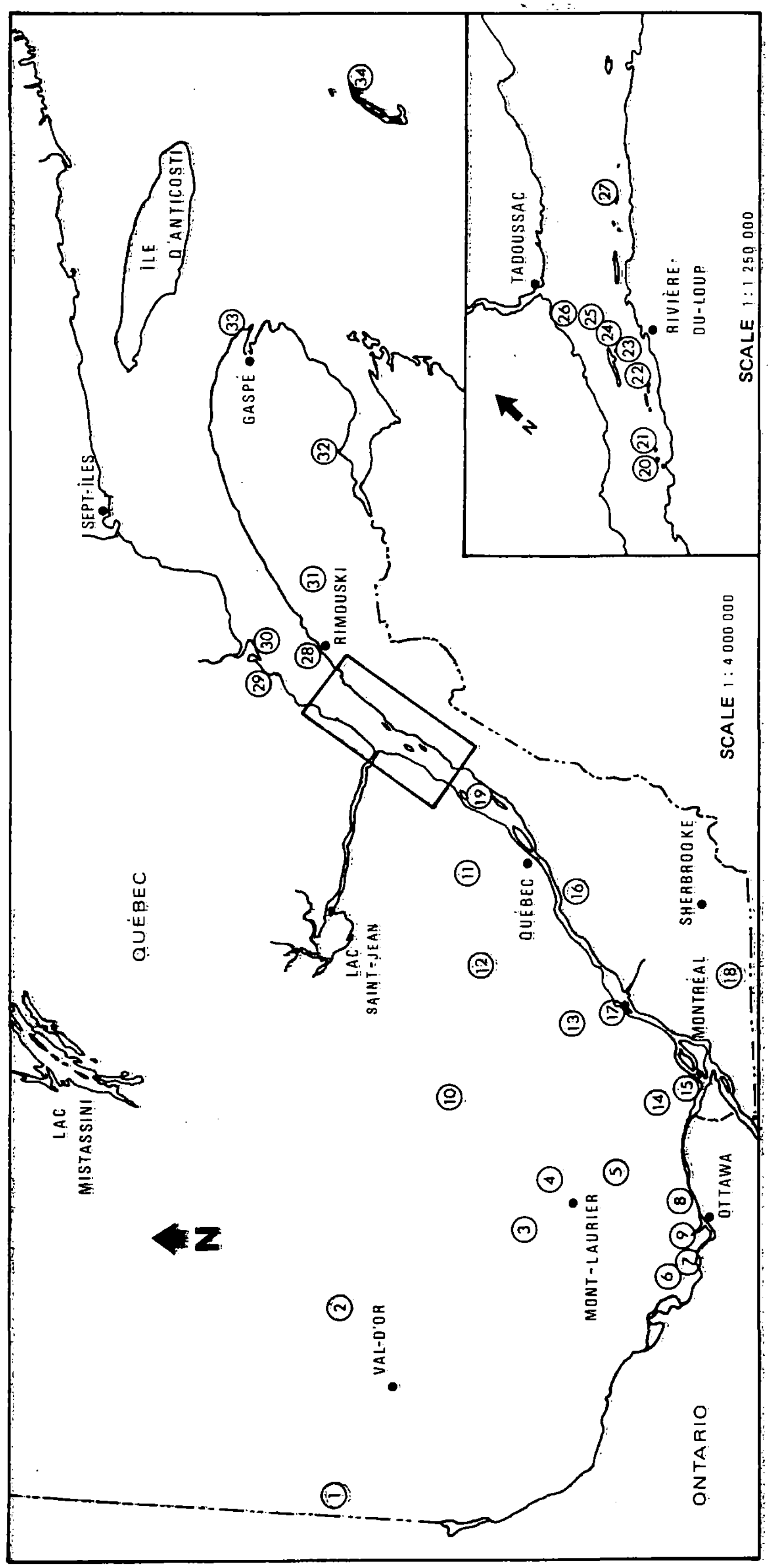

Figure 1
Southern Quebec region. Numbers indicate heronries inspected in 1978, as listed in Table 1

Two sparsely populated heronries were abandoned in 1978: the colonies at Ruisseau Beaudry, in the Gaspé, and on Îlet du Pot à l'Eau-de-Vie in the St. Lawrence estuary. In the latter case, it is likely that the colony had moved to the neighbouring island, namely Île du Pot à l'Eau-de-Vie.

Population trends

In recent years, and more specifically from 1977 to 1978 (24 of 34 colonies visited in 1978 had been visited in 1977), the number of platforms has declined in 67% of the heronries compared.

The number of occupied nests has also declined in 64% of the 14 colonies for which we have such data. However, these reductions are not statistically significant (Wilcoxon test, $p > 0.05$). The largest reductions occurred in the Outaouais region and the St. Lawrence estuary. In the former, the number of platforms and occupied nests declined in all three of the heronries studied; significant losses were also recorded in the latter, where platforms disappeared in five of the eight colonies studied, and the number of active nests declined in three of the four colonies for which we have such data. The most dramatic decline occurred at Île le Gros Pèlerin, where 27 of the 50 nests occupied in 1977 were abandoned in 1978. This decrease was very likely due to activity within the colony by biologists and film-makers during the early spring.

In the Eastern Townships and the Gaspé, the number of active nests increased in four of the five heronries for which such data had been collected. The most spectacular increase in the Eastern Townships was recorded on Grande Île, where the number of active nests rose from 50 to 145 in one year. In the Gaspé, the number of active nests in the Maria colony increased from 55 to 80 during the same period.

These population increases offset the losses suffered elsewhere, and show a net gain for the survey as a whole (Table 2). From 1977 to 1978, the total number of occupied nests for all colonies visited during both years increased by 16%.

Average number of eggs per nest

By way of an exception this year, we flew by helicopter over eight heronries in the St. Lawrence estuary during the incubation period (on 24 May and 1 June). This allowed us to count the eggs in many nests (Table 3). The average number of eggs per nest in the estuary was 4.0 ($S_{\bar{x}} = 0.2$), with no significant difference apparent between colonies (ANOVA, $F_{7,69,\,0.05} = 2.17$) (DesGranges 1978*b*).

Reproductive success

The average number of young herons produced per successful brood in a colony was approximately 2.24 ($S_{\bar{x}} = 0.60$) in 1978, compared with 2.13 ($S_{\bar{x}} = 0.55$) for the heronries visited in 1977 (Table 1). Even though this difference in the survival rate may not be significant on a province-wide scale ($t = 0.66$, df = 27, $p > 0.25$), the average survival of broods may nevertheless have been greater this year in the Outaouais region. In fact, each of the three heronries in that region for which this parameter was studied, showed greater reproductive success in 1978 compared with the previous year.

We know the percentage of successful broods for only four heronries (Table 4). For these, we can calculate the average survival rate of hatched clutches. In three of the four colonies, this value falls below 1.9. Henny (1972) calculated that the average survival rate of Great Blue Heron broods living in the northern United States would have to be approximately 1.9 young per active nest for the population to remain stable. We regard this as perhaps the cause of the reduction in size of several Quebec heronries in recent years.

Thickness of eggshell fragments and contamination by organochloride compounds

The first inspection tour of Quebec heronries yielded eggshell fragment samples from 12 different heronries. In 1978, we collected eggshell fragments from seven colonies, three of which had been visited in 1977 (Table 1).

A comparison of measurements for 1977 with those of 1978 revealed no significant difference between fragments collected on Île aux Basques and at Lac Matapédia (Wilcoxon test, $p > 0.05$). Conversely, the study of the Lac Duparquet colony showed a significant increase in the average thickness of fragments (Wilcoxon test, $p < 0.05$). This increase is not readily explainable at this time; further data will have to be accumulated. The five new colonies fall within the variation interval established for the colonies surveyed in 1977.

The thickness of Great Blue Heron eggshells in southern Canada before 1947 has been estimated at 39.3×10^{-3} cm (Anderson and Hickey 1972). This measurement, however, applies to relatively fresh eggs. We are still unable to establish the relationship between the shell thickness of fresh eggs and that of eggshell fragments after incubation. Kreitzer (1972) reported a 7.3% reduction in eggshell thickness during incubation of Japanese Quail (*Coturnix japonica*). If such a factor applies to our data, we may assume that the majority of Great Blue Herons in Quebec are not significantly affected by the eggshell thinning syndrome, since the average thickness of eggshells collected beneath nests in 1978 was 35.8×10^{-3} cm ($S_{\bar{x}} = 0.29$), or 8.9% less than that of fresh eggshells collected before 1947.

Two fresh eggs were collected from different colonies and analyzed to determine their concentrations of organochloride compounds and polychlorinated biphenyls (PCBs). The results of these analyses are listed in Table 5. DDE and dieldrin residue levels measured below the averages reported for Wisconsin and Texas (Faber and Hickey 1973, King *et al.* 1978), except the dieldrin concentration found in the egg collected at Maria, which was comparable to the level found in Wisconsin. This particular heronry's higher organochloride and PCB concentrations, however, may be attributed to its location in Baie des Chaleurs, which is more industrialized than the Lac Saint-Bernard area in the Laurentians. The analyses planned for next year should enable us to determine more precisely the extent of Great Blue Heron egg contamination in Quebec.

Table 1
Characteristics of heronries inspected in 1978

Location of colony	Position	Nests occupied* at next to last visit and year of count	Platforms at next to last visit and year of count	Nests occupied in 1978*	Plat-forms in 1978	Average survival of successful broods (no. young/nest)† 1977/78	Average thickness of shell fragments (10^{-3} cm) 1977/78	Sources‡
Northwestern Quebec								
1. Lac Duparquet	48°28'N; 79°17'W	–	20 (1977)	24	26	– / –	32.3(0.6)/35.8(0.1)#	2,6,13
2. Lac Martin	48°27'N; 76°49'W	–	–	? "	35	– / –	– / –	22
Outaouais								
3. Lac Marguerite	46°57'N; 75°48'W	–	25 (1977)	20	24	– /2.0	– /35.0(0.6)	6,27
4. Lac Lacordaire	46°42'N; 75°10'W	–	–	?	25	– / –	– / –	9
5. Lac Robillard	46°11'N; 75°08'W	–	25 (1977)	11	15	– /3.0(0.3)	– / –	2,6,27
6. Glynn Lake	45°38'N; 76°14'W	16 (1977)	27 (1977)	4	13	1.8(0.1)/2.0(0.0)	– / –	4,18
7. Power Line Lake	45°37'N; 76°07'W	15 (1977)	18 (1977)	9	11	1.9(0.2)/2.1(0.3)	– / –	4,18
8. Prairie de Castor	45°37'N; 75°29'W	–	–	?	50	– / –	– / –	25
9. Long Lake	45°36'N; 75°57'W	13 (1977)	13 (1977)	10	10	2.3(0.3)/2.6(0.3)	– / –	4,18
Laurentians								
10. Lac Manouane	47°34'N; 74°08'W	–	–	?	25	– / –	– / –	24
11. Petit Lac Jacques-Cartier	47°24'N; 71°33'W	–	–	?	25	– / –	– / –	16
12. Lac Wayagamac	47°21'N; 72°39'W	–	135 (1971)	41	50	– /2.2(0.2)	– / –	2,6,21
13. Lac Saint-Bernard	46°32'N; 73°18'W	35 (1977)	44 (1977)	29	35	2.4(0.2)/1.6(0.1)	– /37.3(0.5)	4,10
14. Lac Dye	45°51'N; 74°18'W	–	–	5	5	– /2.0(0.0)	– / –	29
Southwestern Quebec								
15. Baie d'Oka	45°28'N; 74°03'W	50 (1977)	66 (1977)	50	63	2.7(0.2)/ –	– / –	4,17
Eastern Townships								
16. Rivière Huron	46°31'N; 71°48'W	–	10 (1977)	–	8	– / –	– / –	2,6,8
17. Grande Île	46°06'N; 72°57'W	50 (1977)	50 (1977)	145	182	– / –	– /36.0(0.6)	11
18. Cowansville	45°11'N; 72°44'W	20 (1977)	20 (1977)	21	31	– / –	– /38.5(0.4)	4,15

(cont'd)

Table 1 *(cont'd)*
Characteristics of heronries inspected in 1978

Location of colony	Position	Nests occupied* at next to last visit and year of count	Platforms at next to last visit and year of count	Nests occupied in 1978*	Plat-forms in 1978	Average survival of successful broods (no. young/nest)† 1977/78	Average thickness of shell fragments (10^{-3} cm) 1977/78	Sources‡
Estuary								
19. Battures aux Loups Marins	47°14'N; 70°25'W	–	–	8	8	– /2.0(0.5)	– / –	3,5,7
20. Île Brûlée	47°37'N; 69°52'W	15 (1977)	31 (1977)	?	11	1.9(0.3)/ –	– / –	3,4,7
21. Grande Île	47°38'N; 69°51'W	–	19 (1977)	?	31	2.5(0.2)/ –	– / –	3,4,7
22. Île le Gros Pèlerin	47°44'N; 69°41'W	50 (1977)	66 (1977)	23	48	2.0(0.2)/2.1(0.3)	– / –	3,4,7
23. Île du Pot à l'Eau-de-Vie	47°52'N; 69°41'W	–	–	7	7	– / –	– / –	7
24. Îlet du Pot à l'Eau-de-Vie	47°52'N; 69°41'W	2 (1977)	3 (1977)	0	0	1.0 / –	– / –	4,7
25. Île Blanche	47°56'N; 69°41'W	2 (1977)	4 (1977)	1	2	2.0 / –	– / –	4,7
26. Île du Chafaud aux Basques	48°02'N; 69°46'W	9 (1977)	9 (1977)	?	25	1.7(0.2)/ –	– / –	3,4,7
27. Île aux Basques	48°08'N; 69°15'W	20 (1977)	28 (1977)	29	29	2.4(0.2)/1.7(0.2)	38.2(0.9)/38.8(0.5)	3,4,7
28. Île Saint-Barnabé	48°26'N; 68°37'W	55 (1977)	62 (1977)	?	56	2.7(0.1)/2.5(0.7)	38.2(0.3)/ –	3,4,20
North Shore								
29. Rivière Papinachois	49°01'N; 68°39'W	–	–	10	10	– / –	– / –	1
30. Pointe aux Outardes	49°03'N; 68°26'W	–	45 (1977)	47	65	– /2.5(0.5)	– / –	2,6,14
Gaspé								
31. Lac Matapédia	48°35'N; 67°37'W	20 (1977)	22 (1977)	25	26	– / –	33.7(0.6)/35.8(0.8)	4,28
32. Maria	48°13'N; 65°58'W	55 (1977)	70 (1977)	80	97	2.0(0.3)/3.0(0.1)	35.4(0.8)/ –	4,23
33. Ruisseau Beaudry	48°51'N; 64°27'W	8 (1977)	20 (1977)	0	9	2.6(0.4)/ –	36.2(0.6)/ –	2,3,4,19
Magdalen Islands								
34. Île aux Loups Marins	47°36'N; 61°29'W	24 (1977)	–	16	–	– / –	– / –	4,12

*A nest is considered occupied if there is no doubt it was used by a pair during the nesting season, even if no young were produced.
†A brood is considered successful if at least one young heron is alive in the nest less than 10 days before the first young herons leave the colony.
‡The following sources are listed in the References: (1) Club des ornithologistes du Québec 1978, (2) DesGranges 1978*a*, (3) DesGranges 1978*b*, (4) DesGranges *et al* 1979, (5) DesGranges 1979, (6) DesGranges in preparation. The following sources are personal communications: (7) J.-L. DesGranges, (8) R. Angers, (9) Y. Bédard, (10) D. Bordeleau, (11) M. Bureau, (12) J. Burton, (13) J. Chabot, (14) G. Chapdelaine, (15) J. J. Dubois, (16) C. Fortin, (17) F. Gaudreau, (18) S. Hamill, (19) J.M. Hudon, (20) J.P. Lebel, (21) J. Létourneau, (22) J.P. Létourneau, (23) B. Lyon, (24) Y. Maillot, (25) Y. Morriset, (26) R. Simard, (27) D. St-Hilaire, (28) R. Tardif, (29) M. Zazvorka.
"A question mark indicates that the heronry was active, but with the number of occupied nests unknown. A dash indicates no data available.
#Average standard deviation.

Table 2
Comparative number of occupied nests in colonies inspected in both 1977 and 1978

Region	Colonies inspected in 1977 and 1978*	Occupied nests 1977	Occupied nests 1978	Change (%)
Outaouais	3	44	23	-48
Laurentians	1	35	29	-11
Southwestern Quebec	1	50	50	0
Eastern Townships	2	70	166	+137
Estuary	4	74	53	-28
Gaspé	3	83	105	+27
Magdalen Islands	1	24	16	-33
Total	15	380	442	+16

*This figure includes only those heronries for which such data are available.

Table 3
Average number of eggs laid in eight heronries of the St. Lawrence estuary

Heronries	Active nests	Sample size	Av. no. eggs laid	Standard deviation
Île à Deux Têtes	21	12	3.9	0.5
Battures aux Loups Marins	8	4	3.0	0.8
Île Brûlée	15	7	3.9	0.8
Grande Île de Kamouraska	31	17	4.4	1.1
Île le Gros Pèlerin	23	7	4.1	0.7
Île du Chafaud aux Basques	25	10	4.0	0.8
Île aux Basques	29	9	4.3	1.6
Île Saint-Barnabé	28	11	4.3	0.6
Total	–	–	4.0	0.4

Variance analysis	Degrees of freedom	Sum of error squares	Variance estimates	F ratio
Inter-heronry	7	8.24	1.18	1.59
Intra-heronry	69	50.93	0.74	
Total	76	59.17	$F_{7,69,\,0.05} = 2.17$	

Table 4
Reproductive success in four heronries studied in 1978

Colony	Hatched clutches	Successful broods*	Successful broods %	Av. no. eggs laid	Av. survival successful broods (young/nest)	Survival in successful broods %	Av. survival hatched clutches (young/nest)	Survival in hatched clutches %	Result†
Lac Robillard	11	11	100	–	3.0 (0.3) ‡	–	3.0	–	+
Lac Saint-Bernard	29	25	86	–	1.6 (0.1)	–	1.4	–	–
Battures aux Loups Marins	8	6	75	3.0 (0.3) ‡	2.0 (0.5)	67	1.5	50	–
Île le Gros Pèlerin	23	18	78	4.1 (0.3)	2.1 (0.3)	51	1.6	39	–

*A brood is considered successful if at least one young heron is alive in the nest less than 10 days before the first young herons leave the colony.

†According to Henny (1972), the average survival rate of hatched clutches should remain at approximately 1.9 young per nest if the population is to remain stable. Thus the population of a heronry is probably stable and perhaps increasing (+) if the calculated average survival rate of hatched clutches exceeds 1.9. Otherwise, the population is probably declining (–).
‡Average standard deviation.

Discussion
All of the ecological data needed to prepare a precise diagnosis of the principal causes of mortality in each heronry cannot be collected in a broad study of this type. In order to do so, we would have to visit each colony several times and record the development of eggs and young herons in each nest. Nevertheless, the data acquired inexpensively by means of inspection tours sometimes allow us to identify the probable causes of mortality within certain colonies. Since heronries are selected according to the availability of helpers, we can assume that they represent a quasi-random sampling which reflects fairly accurately the situation throughout the province.

The causes of mortality act mainly in two ways. They can either bring about the death of the entire brood within a short time, or cause the progressive loss of some eggs and/or occasionally the death of several young herons per brood. Sometimes, both factors act together to varying degrees within a single colony. Since the first type of mortality factors cause the failure of complete broods, we see a low percentage of successful broods in affected heronries. In the second case, where many broods have been depleted, we see a low average rate of survival among successful broods. Table 6 depicts all four possible situations and indicates the principal factors causing mortality in each case.

The data collected in 1978 enabled us to calculate both the percentage of successful broods and the average survival rate for only four colonies (Table 4). In each case, we found a high percentage of successful broods. Nest abandonment, poor weather conditions, parasites, disease, egg infertility, interspecific competition and the poaching of adults may therefore be discounted as principal causes of mortality (see causes exclusive to the left-hand quadrants in Table 6). The average survival rate of successful broods, however, was low in all cases except at Lac Robillard, where egg and young heron losses were minimal and probably resulted from isolated accidents or normal mortality due to a combination of the previously mentioned factors (see lower right-hand quadrant in Table 6). In the three other colonies, the substantial but partial reduction in the size of broods was apparently caused by a single mortality factor, possibly a food shortage, judging at least by the research work of others on the reproduction of ciconiiformes (see upper right-hand quadrant in Table 6). Having found only a very few dead young on the ground, we are unable to state positively that this was the main cause of mortality. It is possible, however, that the young died very early and their carcasses became integrated with the structure of the nests, in which case their death may have gone unnoticed. We hope to collect the data needed to clarify this point in the years to come.

Widespread famine, disease, parasites, and the poaching of young and adult birds are probably not significant causes of mortality in Quebec heronries. In fact, no heron carcasses

Table 5
Organochloride and polychlorinated biphenyl (PCB) residues found in two analyzed fresh eggs

Residue*	Lac Saint-Bernard	Maria
DDE	1.27	3.38
Dieldrin	0.08	0.42
pp'DDT	0.03	0.07
Heptachlor epoxide	0.20	0.34
Oxychlordane	0.14	0.09
Hexachlorobenzene	0.01	0.03
PCB (1260)	6.49	8.86
Eggshell thickness (10^{-3} cm)	36.8	36.8

*Values expressed in ppm (wet weight).

were found on the ground beneath nests in any of the colonies inspected. Egg infertility related to the thinning of shells by certain toxic substances is another possibility that can be readily discounted, given the apparently normal thickness of eggshell fragments collected from beneath nests. As for poor weather conditions, no exceptional cold snaps or periods of frequent and abundant precipitation were recorded in southern Quebec during the 1978 nesting season (Appendix 1). It did rain often in June, however, in the northwestern part of the province and along the North Shore of the St. Lawrence.

Table 6
Probable causes of mortality among eggs and young herons*

Average survival of successful broods	Percentage of successful broods: Low	Percentage of successful broods: High
Low	Abandonment (15)† Starvation (1,6,8) Weather (1,6,8) Parasites & disease (9, 18) Infertility (3,9,10) Excessive predation (1,6,8,11,14,15)	Shortage of food (4,7,9)
High	Abandonment (13,16,17) Weather (4,12) Parasites & disease (9) Infertility (9) Interspecific competition (2) Death of parents	Normal mortality due to a combination of all factors (4,5,15) Accidents (4,5)

*Based in part on Ricklefs 1969.
†Sources: (1) Baker 1940, (2) Dusi and Dusi 1968, (3) Faber *et al* 1972, (4) Hafner 1978, (5) McAloney 1973, (6) Miller and Burger 1978, (7) Owen 1960, (8) Parsons 1977, (9) Pratt 1974, (10) Price pers. com., (11) Quinney and Smith 1979, (12) Simmons 1959, (13) Simpson and Kelsall 1978, (14) Taylor and Michael 1971, (15) Teal 1965, (16) Tremblay and Ellisson 1979, (17) Werschkul *et al* 1976, (18) Wiese *et al* 1977.

This abundant rainfall may have caused the loss of a few broods in these areas. Finally, few pairs seem to have abandoned their nests after laying their eggs. It is possible, however, that some pairs deserted the colony where they planned to nest due to over-frequent disturbances during the 1977 nesting season or the 1978 mating season. This is probably the cause of the considerable reduction in the number of active nests in the heronry on Île le Gros Pèlerin.

The methodology used in this study is not foolproof. It is often difficult to differentiate active from vacant nests or to count the exact number of young per nest. Since we distinguish between accurate and unreliable data in the field, however, we can calculate realistic averages and compare colonies on the basis of these parameters. We also ask our workers to visit, wherever possible, the same heronry each year. This allows them to acquire a sound knowledge of the colony assigned to them, and if they make any errors, they are very likely to repeat them regularly from one year to the next, thus reducing the significance of errors in inter-annual comparisons. We inventory each colony on or about the same date each year and make our visits over a short period. This enables us to obtain more readily comparable data, since nesting phenology normally varies little from year to year. In years when egg-laying is delayed, the data cannot be compared so precisely and the conclusions drawn from them are necessarily less accurate. Ultimately, since all heronries are not inventoried annually, we cannot deny the possibility that losses in some heronries may contribute to the increased population of others or the formation of new heronries. If that were the case, Great Blue Heron populations in Quebec could have remained stable or increased despite the reduction in the size of colonies. We think this possibility is unlikely, however, because we found very few newly established colonies during the course of our first two tours of inspection.

Acknowledgements
We offer our sincere thanks to the many people who helped us. The names of the team leaders who participated in the tour are listed at the bottom of Table 1. Jacques Rosa, CWS, drafted the map reproduced in Figure 1, and the contents of this report were discussed with Jacqueline Tremblay, Austin Reed and Iola M. Price, who are also with CWS. Finally, Transport Canada placed a helicopter at our disposal for use in the St. Lawrence estuary.

References

Anderson, D.W.; Hickey, J.J. 1972. Eggshell changes in certain North American birds. Pages 514-40 *in* Proc. XVth International Ornithological Congress.

Anonyme. 1971. Température et précipitations 1947–1970, Québec. Service de l'environnement atmosphérique. Environnement Canada. 65 pp.

Anonyme. 1977–78. Bulletin météorologique. Service de la météorologie. Direction générale des eaux. Ministère des Richesses naturelles. Québec. 16:5, 6, 7; 17:5, 6, 7.

Baker, R.H. 1940. Crow depredations on heron nesting colonies. Wilson Bull. 52:124–125.

Buckley, P.A.; Buckley, F.G. 1976. Guidelines for protection and management of colonially nesting waterbirds. U.S. Natl. Park Serv. 54 pp.

Club des ornithologistes du Québec. 1978. Bulletin ornithologique. 23:82.

DesGranges, J.-L. 1978*a*. Les Grands Hérons du Parc national Forillon. SCF et Parcs Canada. Rap. tech. v + 80 pp.

DesGranges. J.-L. 1978*b*. Adaptive value of social behaviour in the Great Blue Heron (*Ardea herodias*). Proc. Colonial Waterbird Group. 1978:192–201.

DesGranges, J.-L. 1979. Abandoned windmill used as a nesting site by Great Blue Herons. Can. Field-Nat. 93.

DesGranges, J.-L.; Laporte, P.; Chapdelaine, G. 1979. First tour of inspection of Quebec heronries, 1977. Can. Wildl. Serv. Prog. Notes 93: 1–4.

Dusi, J.L.; Dusi, R.T. 1968. Ecological factors contributing to nesting failure in a heron colony. Wilson Bull. 80:458–466.

Faber, R.A.; Risebrough, R.W.; Pratt, H.M. 1972. Organochlorines and mercury in common egrets and great blue herons. Environ. Pollut. 3:111–122.

Faber, R.A.; Hickey, J.J. 1973. Eggshell thinning, chlorinated hydrocarbons, and mercury in inland aquatic birds eggs, 1969 and 1970. Pestic. Monit. J. 7:27–36.

Hafner, H. 1978. Le succès de reproduction de quatre espèces d'ardéidés (*Egretta g. garzetta, Ardeola r. ralloides, Ardeola i. ibis, Nycticorax n. nycticorax*) en Camargue. Terre Vie 32:270–290.

Henny, C.J. 1972. An analysis of the population dynamics of selected avian species: with special reference to changes during the modern pesticide era. Wildl. Res. Rep. 1, U.S. Fish and Wildl. Serv. 99 pp.

King, K.A.; Flickinger, E.L.; Hildebrand, H.H. 1978. Shell thinning and pesticide residues in Texas aquatic bird eggs. 1970. Pestic. Monit. J. 12:16–21.

Kreitzer, J.F. 1972. The effect of embryonic development of thickness of the eggshells of Coturnix Quail. Poult. Sci. 51:1764–1765.

McAloney, K. 1973. The breeding biology of the Great Blue Heron on Tobacco Island. Nova Scotia, Canada. Can. Field-Nat. 87:137–140.

Miller, L.M.; Burger, J. 1978. Factors affecting nesting success of the Glossy Ibis. Auk 95:353–361.

Owen, D.F. 1960. The nesting success of the heron *Ardea cinerea* in relation to the availability of food. Proc. Zool. Soc. London. 133:597–617.

Parsons, J. 1977. The effect of predation by fish eagles on the breeding success of various ciconiiformes nesting near Kisumu, Kenya. J. Nat. Hist. 11:337–353.

Pratt, H.M. 1974. Breeding of Great Blue Herons and Great Egrets at Audubon Canyon Ranch, California, 1972–73. West. Birds 5:127–136.

Quinney, T.W.; Smith, P.C. 1979. Reproductive success, growth of nestlings and foraging behaviour of the Great Blue Heron (*Ardea herodias herodias L.*). Can. Wildl. Serv. Unpubl. tech. rep. 151 pp.

Reed, A. 1973. Aquatic bird colonies in the St. Lawrence estuary. Serv. Faune Québec. Bull. 18:1–54.

Ricklefs, R.E. 1969. An analysis of nesting mortality in birds. Smithson. Contrib. Zool. 9:1–48.

Simmons, E.M. 1959. Observations on effects of cold weather on nesting Common Egrets. Auk 76:239–241.

Simpson, K.; Kelsall, J.P. 1978. Capture and banding of adult Great Blue Herons at Pender Harbour, British Columbia. Proc. Colon. Waterbird Group 1978:71–78.

Taylor, R.J.; Michael, E.D. 1971. Predation on an inland heronry in eastern Texas. Wilson Bull. 83:172–177.

Teal, J.M. 1965. Nesting success of egrets and herons in Georgia. Wilson Bull, 77:257–263.

Tremblay, J.; Ellison, L.N. 1979. Effects of human disturbance on breeding of Black-crowned Night Herons. Auk 96:364–369.

Werschkul, D.F.; McMahon, E.; Leitschuh, M. 1976. Some effects of human activities on the Great Blue Heron in Oregon. Wilson Bull. 88:660–662.

Wiese, J.H.; Davidson, W.R.; Nettles, V.F. 1977. Large scale mortality of nestling ardeids caused by nematode infection. J. Wildl. Dis. 13:376–382.

Appendix 1
Temperature and precipitation in southern Quebec during 1977 and 1978 nesting seasons*

Regions and stations	Year	Av. min. temp. (°F) May	June	July	Rainfall (in.) May	June	July	Days of measurable rain May	June	July
Northwestern Quebec										
La Sarre	77	**40.3**	44.1	52.1	0.73	4.23	2.23	7	13	11
	78	–	41.8	49.7	–	4.99	4.61	–	17	16
Val-d'Or	77	39.7	43.7	49.8	0.49	4.91	3.54	6	15	14
	78	**40.5**	43.9	48.7	1.87	3.03	3.06	13	**20**	16
Barrage-Témiscamingue	77	40.5	48.4	56.4	1.31	3.56	4.54	7	17	12
	78	42.1	46.7	54.0	1.85	4.35	4.67	10	**18**	12
Outaouais										
Fort-Coulonge	77	40.9	–	54.5	1.32	2.45	1.44	8	10	8
	78	41.1	46.3	50.1	1.54	2.09	1.55	8	13	7
Maniwaki	77	–	–	–	–	–	–	–	–	–
	78	41.7	47.5	51.6	1.64	2.89	2.43	8	15	13
Thurso	77	42.6	50.0	56.0	1.81	**5.51**	2.29	9	12	8
	78	45.6	50.9	54.6	1.27	3.31	2.36	7	12	9
Laurentians										
Mont-Laurier	77	40.6	47.7	52.8	1.39	3.82	1.96	8	15	12
	78	43.2	49.5	51.2	1.83	2.69	2.70	9	14	12
Saint-Jérôme	77	43.4	51.8	55.9	0.89	3.72	2.06	4	14	10
	78	**46.5**	52.1	56.9	1.20	2.85	2.51	9	17	10
Shawinigan	77	44.2	54.3	57.2	1.19	**6.00**	2.37	6	14	11
	78	45.5	53.0	57.7	1.48	4.70	2.48	7	16	12
La Tuque	77	39.5	–	53.6	0.60	–	3.54	6	15	9
	78	40.0	50.3	52.7	1.55	**6.50**	4.56	5	16	13
Saint-Féréol	77	38.2	48.9	51.8	1.17	4.83	2.77	6	**17**	9
	78	38.7	50.3	51.4	1.66	3.79	3.32	9	**17**	10
Southwestern Quebec										
Huntingdon	77	45.5	53.0	58.6	1.00	2.62	1.61	6	14	8
	78	48.0	53.2	58.5	2.10	**5.42**	1.86	12	15	11
Oka	77	43.4	51.4	56.9	0.79	3.17	2.61	3	13	11
	78	46.6	52.6	56.3	1.37	3.78	1.73	10	16	8
Dorval	77	44.8	52.9	57.9	0.96	4.20	2.86	4	16	12
	78	48.4	42.3	58.9	1.64	3.50	1.99	10	15	9
Philipsburg	77	45.2	52.3	58.1	0.67	3.27	2.51	5	16	8
	78	47.0	54.8	58.4	2.02	4.95	2.64	8	14	11

(cont'd)

Appendix 1 *(cont'd)*
Temperature and precipitation in southern Quebec during 1977 and 1978 nesting seasons*

Regions and stations	Year	Av. min. temp. (°F) May	June	July	Rainfall (in.) May	June	July	Days of measurable rain May	June	July
Eastern Townships										
Granby	77	46.4	54.4	59.4	1.53	4.75	3.48	8	**21**	10
	78	46.0	54.2	59.1	2.43	**8.61**	4.92	8	17	12
Nicolet	77	46.1	54.0	58.7	1.16	4.09	3.26	5	**19**	11
	78	**48.1**	55.0	58.4	1.34	2.91	1.57	7	**18**	7
Thetford-Mines	77	43.0	49.8	54.0	1.96	6.39	2.04	8	**22**	10
	78	43.7	49.8	–	1.74	6.49	–	9	**20**	–
Lac Mégantic	77	40.7	50.0	54.0	1.53	6.01	1.68	7	18	8
	78	42.3	50.5	56.8	2.52	5.82	3.98	11	14	12
Armagh Station	77	42.6	49.5	53.3	0.93	4.96	2.52	7	**20**	9
	78	42.4	51.9	52.9	1.94	4.77	2.24	9	17	8
Estuary										
La Pocatière	77	43.0	–	–	1.23	–	–	8	–	–
	78	41.0	52.8	55.0	1.17	3.00	1.83	11	16	10
La Malbaie	77	41.0	49.8	51.5	0.09	5.58	0.83	3	**21**	6
	78	40.6	49.6	–	1.12	2.93	–	8	14	–
Trois-Pistoles	77	40.8	48.0	–	1.11	4.67	–	9	15	–
	78	38.7	49.3	53.8	2.78	3.23	1.88	12	17	12
Pointe-au-Père	77	40.6	48.1	–	1.43	3.91	–	9	12	–
	78	39.1	48.9	52.8	2.36	2.95	2.23	7	12	10
North Shore										
Grandes Bergeronnes	77	40.8	48.6	52.5	0.45	**9.35**	4.18	5	16	10
	78	39.8	47.9	52.6	2.90	3.98	3.17	11	**18**	13
Baie-Comeau	77	37.8	46.6	48.0	1.90	4.97	3.05	11	16	12
	78	37.0	47.6	50.2	2.97	2.82	1.23	10	**19**	11
Gaspé										
Causapscal	77	36.6	48.2	49.5	2.63	5.00	3.41	13	**20**	12
	78	36.8	48.0	51.4	2.67	3.29	4.09	8	17	12
Caplan	77	38.9	50.0	52.6	2.57	**5.80**	1.33	11	18	11
	78	37.7	50.9	55.8	1.72	2.96	1.61	6	10	10
Gaspé	77	36.4	47.8	52.3	**6.14**	4.85	2.18	16	16	11
	78	34.8	49.0	53.8	2.12	1.76	2.35	11	10	13
Cap-Chat	77	38.6	47.7	53.1	2.36	2.86	2.11	12	12	9
	78	36.5	46.9	54.0	4.06	2.45	3.44	10	14	9

(cont'd)

Appendix 1 (*Conc.*)
Temperature and precipitation in southern Quebec during 1977 and 1978 nesting seasons*

Regions and stations	Year	Av. min. temp. (°F)			Rainfall (in.)			Days of measurable rain		
		May	June	July	May	June	July	May	June	July
Magdalen Islands										
Cap-aux-Meules	77	36.1	45.9	55.6	2.48	2.21	2.69	14	15	13
	78	37.2	47.7	56.7	0.94	2.83	2.13	8	16	11

*These data are drawn from the *Bulletins météorologiques* (Meteorological bulletins) issued monthly by the Quebec Department of Natural Resources (Anon. 1977–78). Those which differ somewhat from the average statistics supplied by Environment Canada (Anon. 1971) for these areas are printed in different typefaces. **The larger** numbers indicate either an average minimum temperature at least 5°F above average, rainfall at least 2 in. above average, or a number of measurable-rain days at least 7 days above average. **The smaller** numbers, which are also underlined, indicate similar differences, but on the minus side of the scale. Locations were selected so as to provide climatological data from all parts of southern Quebec.