MINNESOTA MUSEUM OF NATURAL HISTORY

UNIVERSITY OF MINNESOTA

MINNEAPOLIS, MINNESOTA 55455

CFSTI PRICES

H.C. \$ 3.00 MN. 75

MASTER

PROGRESS REPORT

UNITED STATES ATOMIC ENERGY COMMISSION
CONTRACT AT(11-1)-1332

EFFECTS OF IONIZING RADIATION AND OTHER
ENVIRONMENTAL FACTORS ON BREEDING BEHAVIOR,
ACTIVITY PATTERNS AND MOVEMENT OF SELECTED VERTEBRATES

JULY 1966

RELEASED FOR ANNOUNCEMENT

IN NUCLEAR SCIENCE ABSTRACTS

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

Principal Investigator: Dr. John R. Tester

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Institution and Address:

Minnesota Museum of Natural History
University of Minnesota
Minneapolis, Minnesota 55455

Principal Investigator:

Dr. John R. Tester, Ecologist and Associate Professor,
Museum of Natural History

Project Titles:

Overall Project Title:

EFFECTS OF IONIZING RADIATION AND OTHER ENVIRONMENTAL
FACTORS ON BREEDING BEHAVIOR, ACTIVITY PATTERNS AND
MOVEMENT OF SELECTED VERTEBRATES.

Subproject Titles:

- (1) EFFECTS OF IONIZING RADIATION ON PAIR-FORMATION IN THE
GREEN-WINGED TEAL, ANAS CRECCA CAROLINENSIS.
- (2) EFFECTS OF IONIZING RADIATION ON TERRITORIAL BEHAVIOR
IN THE SHOVELER, ANAS CLYPEATA.
- (3) EFFECTS OF IONIZING RADIATION ON RE-NESTING IN THE BLUE-
WINGED TEAL, ANAS DISCORS.
- (4) BIOLOGICAL, BEHAVIORAL AND PHYSICAL FACTORS AFFECTING
HOME RANGES OF SNOWSHOE HARES (LEPUS AMERICANUS),
RACCOONS (PROCYON LOTOR) AND WHITE-TAILED DEER
(ODOCOILEUS VIRGINIANUS) UNDER NATURAL CONDITIONS.
- (5) EFFECTS OF IONIZING RADIATION ON HOME RANGE AND
MOVEMENTS OF SNOWSHOE HARES AND RACCOONS.

Contract Number:

AT (11-1)-1332

Current Request from AEC:

Amount: \$81,126

Period: October 15, 1966 to October 14, 1967

TECHNICAL PROGRESS REPORT: JULY 1965--JUNE 1966

Project Summary

The objectives of this project are to determine the effects of ionizing radiation and other environmental factors on breeding behavior, activity patterns and movement of selected vertebrates and to interpret these effects in terms of their possible influence on population dynamics. LD₅₀₋₃₀'s will be determined when possible for the species under investigation.

Effects of ionizing radiation on populations have been studied to some degree with regard to lethality and sterility. Possible effects of lower levels on population dynamics of vertebrates have not been investigated. In this project radiation is considered as an environmental stress factor and results are evaluated both in terms of the individual and of the population.

Project objectives are being attained by both laboratory and field investigations. Research on SUBPROJECTS 1, 2, 4 and 5 is being conducted at the Cedar Creek Natural History Area 35 miles north of Minneapolis. Field aspects of SUBPROJECT 3 are being carried out on marsh areas in north-central Iowa. Results by subprojects follow:

1. On May 18, 1966 four groups of nine Green-winged Teal males were exposed to 400r, 600r, 800r, and 1000r. The LD₅₀₋₃₀ for these birds was 485r. Films of social courtship activities have been analysed to give information on the nature and extent of individual variations, and variations correlated with age and season. In general, these differences appear to be minor. Tape recordings were made of the vocalizations accompanying social courtship, and slow-motion films were made of certain rapid display movements. Experiments involving the introduction of a female to a single male provided information on the role of other males in producing displays in typical courtship groups where many males are present. Studies to date have yielded much information on the normal process of pair-formation and attention will now be concentrated on radiation effects. An attempt to determine immediate effects of 400r and 600r doses of ionizing radiation on courtship behavior was for the most part unsuccessful.
2. On October 20, 1965, four groups of eight Shovelers were exposed to 500r, 700r, 900r, and 1100r. The LD₅₀₋₃₀ for these birds was 894r. Dominance relations in the captive flock were studied during the winter 1965-66. There is a tendency for females to be dominant in early winter, males in late winter. This change coincides with the most active period of pair-formation. A male's rank in his winter flock gave little indication of his subsequent level of aggressiveness in the breeding pens. Eight pairs of yearlings were introduced to the breeding pens on May 3, 1966. Territories had become stable by May 23. On May 24, one male from each pen was given 400r. Intensive observations on these birds until the end of the territorial period (June 28) failed to reveal any significant effects of the radiation treatment.
3. Results of field studies on reneesting in the Blue-winged Teal are presented. In 1965, 141 females and 51 males were individually marked with numbered nasal tabs. Thirteen of these females (11

adults and 2 yearlings) had been banded on the study area in 1964. The nests of 9 of these hens were found. The mean distance of these nests from the 1964 nests of the same birds was 459 feet (range 64 to 1405 feet). Eighteen of the 275 nests found in 1965 were known to be renests. In general there appears to be no "renesting interval" until the clutch is nearly complete. If a nest is destroyed before the female has laid 7 eggs, she continues to lay one egg per day in a new site. The renesting interval tends to become longer as incubation of the initial nest progresses. The average distance between initial nests and renests was 639 feet. The 1966 breeding season was delayed several weeks by cold weather. Of the birds marked in 1965, 14 hens returned to the study area. Seven of the 127 nests found to date are known renests of 4 marked hens. Field studies on this subproject will terminate at the close of the nesting season.

4. Studies began on this subproject in 1964. To date a total of 17 deer, 64 raccoon and 15 snowshoe hares have been radio-tagged and studied for varying periods. Field investigations are currently in progress on raccoons and hares and deer studies will again be initiated in fall, 1966. Data on movements, behavior, mortality, population dynamics, etc., of all radio-tagged animals are currently being analyzed and numerous manuscripts have been prepared (See PUBLICATIONS section of this PROGRESS REPORT).

Because of the mass of data collected on raccoons by the automatic radio tracking system, we have temporarily decreased the scope of our field studies and are currently concentrating on data analysis and preparation of manuscripts. This will provide the basis for future ecological field investigations and will serve as baseline information for evaluating radiation effects. Specific analyses include seasonal weight changes, mortality, population dynamics, intensity of use and extent of home range of 55 animals monitored by radio tracking during a one year period. In addition, daily resting sites of selected animals are being analyzed and a study is in progress on the behavior and movements of reproductive females and their young. Completed investigations for which manuscripts have been submitted include a study of fall daytime resting sites, movements of one young male for 135 days, and abandonment of young during the breeding season.

Data on deer movements and behavior during 1964 and 1965 are still being analyzed. Completed investigations include an evaluation of animal location data obtained by triangulation based on real and simulated deer movements, and studies of bedding habits and winter and spring movements and behavior.

Data on snowshoe hare movements obtained in early 1964 have been analyzed and a detailed evaluation of daily activity rhythms of both snowshoe hares and cottontail rabbits has been accepted for publication. Transmitters were put on 11 snowshoe hares (3 females and 8 males) during March and April, 1966. One female died two days after release. Two males died in traps when recaptured and foxes killed two males. Transmitters quit on two males after functioning for 32 and 53 days. Continuous information has been obtained on the other four animals for approximately 3 months. Attempts are being made to find the young of the two radio-tagged females to determine the relationship of the female with her young.

5. To date we have irradiated only one animal to study effects of ionizing radiation on home range and movements of snowshoe hares and raccoons. This animal, an adult male raccoon, was given a dose of 300r from a cesium-137 source at a rate of 25r per minute on 16 June 1966. Its movements and behavior post-irradiation are being compared with those before exposure and with those of another adult male which we are considering to be a "control" animal. Preliminary analysis of the activities of the irradiated raccoon showed that it moved over approximately half of its total pre-irradiation home range of 3.5 miles by 1.5 miles the first night post-irradiation and that on subsequent days it stayed within its pre-irradiation home range.

In addition to the results summarized above, we have prepared a preliminary draft of a paper describing the results of our LD₅₀ studies of ducks conducted as parts of SUBPROJECTS 1, 2 and 3. This report, titled "Mortality of three species of ducks, Anas discors, A. crecca and A. clypeata, exposed to ionizing radiation", is included as Appendix A of this PROGRESS REPORT.

SUBPROJECT ONE

EFFECTS OF IONIZING RADIATION ON PAIR-FORMATION IN THE
GREEN-WINGED TEAL, ANAS CRECCA CAROLINENSIS

A. Baseline studies

(1) Study of seasonal variation. Experiments involving the introduction of a female to a group of males were unsuccessful in fall 1964, probably because the birds had been kept in small pens during the molting period and the resulting stress seemed to inhibit molting and delayed the onset of fall courtship. In July 1965, the Green-winged Teal were released in the large Shoveler pens and allowed to molt there. In October, the males with most advanced plumage were captured and returned to the filming pens. After allowing them to settle down for several weeks, experiments were carried out on October 27th and 29th, but the response to an introduced female was weak and courtship activity was spasmodic. During the first week of November, experiments were carried out in the large Shoveler pens. In this situation, the birds were much more at ease and fairly active courtship followed. Filming was more difficult in the large pens, but a number of good sequences of active courtship were obtained.

A preliminary analysis of these films shows that virtually all displays and associated activities occur in fall as well as in late spring. Hostility between males was quite common though not as intense as that seen in May and June. The responses of males to females were in general the same as in spring, but most social courtship bouts were shorter and males frequently gave the impression of being disinterested in the female. Detailed comparison of these films with those made in spring should provide the information necessary to establish the nature and extent of seasonal variation in social courtship.

(2) Study of individual variation. Further analysis of films made in 1964 and 1965 has produced more evidence on the nature and extent of individual variations in displays. Differences in speed of movements have now been established for two displays (Grunt-whistle and Down-up). Slight differences in the form of movements have also been noted. For example, some males do not touch the water with the bill at the peak of the Grunt-whistle, whereas most males flick a spray of water-droplets in the direction of the female. Further evidence is also being gathered on individual variations in sequences of displays and their orientation. When they have been fully analysed, the films on hand will be sufficient to document the nature and extent of individual variation.

(3) Study of age variation. A group of juvenile male Green-winged Teal was obtained from the wild in July 1965. These birds were studied intensively in May and June 1966 and films of their courtship behavior were made. These films have not yet been analysed. These individuals will be filmed again in spring 1967, so that a comparison can be made of their behavior in first and second springs. A number of "aberrant" patterns were noted in these males this spring, and it is possible that these are age variations rather than individual peculiarities.

(4) Study of vocalizations. On June 3, 8, and 11, 1966, sound recordings were made of social courtship activity. The birds were filmed simultaneously and it will be possible to correlate the taped sounds with the filmed movements. This will provide the first detailed information on the calls of this species and is an important advance in documenting the normal process of pairing. Already from the tapes a number of previously undetected sounds have been identified, and it is possible that these represent important signals which have been overlooked in the past.

(5) Responses of an isolated male to a female. One of the main problems in interpreting the behavior of individual males during social courtship is the difficulty of deciding the stimulus-response relationships involved. In the typical situation, several males and one female are present and all are actively participating. It is often very difficult to tell whether one bird is reacting solely to the presence of the female and how much his behavior is being influenced by the other males present. In an attempt to throw some light on this problem, experiments were carried out in spring 1966 involving a single male.

In the first four tests, a male Green-winged Teal was placed in a pen with a group of six Shovelers; in two later tests the male was completely alone. Several interesting responses of these isolated males to an introduced female were noted. In two cases, the males gave repeated Grunt-whistles directed at the female (confirming other evidence that this display is not dependent on the presence of other males), but Down-ups were absent (suggesting that this display is in part a response to other males). On one occasion, the male spent much time threatening the Shovelers in the pen, indicating that the increase in male aggressiveness, which is characteristic in the presence of a female, can be directed toward other species when no other teal are present.

(6) Slow-motion films. In June 1966, some film was exposed at 45 frames per second to permit a more detailed analysis of several very rapid display movements.

(7) Film analysis to determine the normal process of pairing. Analysis of films made in 1964 and 1965 has continued and is gradually providing a detailed picture of the normal pair-formation procedure.

A basic problem has been to work out the precise situations in which each display is given, and so to throw light on the environmental factors eliciting them. The distance between birds and the orientation of their bodies have proved to be very important in characterizing the "typical situation" for each behavior pattern (Fig. 1). For example, the Grunt-whistle is performed by a male with very precise lateral orientation of his body to the female, and at a distance of 2 to 5 feet from her. The Down-up is generally given with similar lateral orientation (but not so precise) at a closer distance (1-4 feet). Other males must not be too close when a Grunt-whistle is started, but they usually are very close when a Down-up is given. The male's body orientation is very variable in the case of Turn-back-of-head, but he is almost always in front of the female, often pointing obliquely away from her. Bridling again involves lateral orientation of the male's body with respect to the female, but distance seems relatively unimportant (varying from 2 to 9 feet).

Interactions between the males in the group can be very important in determining whether certain displays are given (Fig. 2). If there is plenty

GRUNT-WHISTLE

DOWN-UP

BRIDLING

TURN-BACK-OF-HEAD

FIG. 1. DIAGRAMS ILLUSTRATING THE DISTANCE BETWEEN MALE AND FEMALE AND THE BODY ORIENTATION OF THE MALE IN RELATION TO THE FEMALE FOR FOUR DISPLAYS. THE ARROW IN THE CENTER OF EACH DIAGRAM REPRESENTS THE FEMALE; THE OTHER ARROWS REPRESENT POSITIONS OF MALES PERFORMING THE DISPLAY. DISTANCE BETWEEN CONCENTRIC CIRCLES IS 1 FOOT. (SEE TEXT FOR DISCUSSION).

FIG. 2. INTERACTIONS BETWEEN THREE MALES DURING SOCIAL COURTSHIP AROUND A FEMALE (CROSS-HATCHED). THE EIGHT DIAGRAMS HAVE BEEN CONSTRUCTED FROM A FILM SEQUENCE. THEY SHOW HOW THE APPROACH OF A MALE CAN PREVENT THE OCCURRENCE OF HEAD-UP-TAIL-UP IMMEDIATELY AFTER A GRUNT-WHISTLE (FRAMES 39 AND 129). IN THE FIRST INSTANCE, THE MALE IS ATTACKED AND AVOIDS IMMEDIATELY AFTER GIVING THE GRUNT-WHISTLE; IN THE SECOND CASE, THE APPROACHING OF THE SAME MALE CAUSES THE THIRD MALE TO BEGIN NOD-SWIMMING AFTER A GRUNT-WHISTLE.

of room, and no danger of interruption by the approach of another male, the Grunt-whistle is usually followed by Head-up-tail-up, Turn-toward-female, Nod-swimming, and Turn-back-of-head. The latter displays may be omitted (or replaced by Nod-swimming only) if the bird is approached while giving the Grunt-whistle.

The typical situation for each display is diagrammed in Fig. 3. Bill-up (BU) often occurs when two males come close together and express hostility (even in the absence of a female). Preen-behind-wing (PBW) occurs after the female has chosen one male, and it is given at very short range. The female's choice is indicated by Inciting movements (INC), involving threats toward other males. Bill-down (BD) is given only when the male is very close to the female and she is still showing strong hostility toward males (including the preferred male in many cases). Jump-flights (JF) are conspicuous short flights across the group of birds, the male often alighting in front of the female. Shake + Belly-preen (Sh + BP) and Bridling (BRID) are important displays when the birds are on land. Burps (B) occur in bursts, with several males calling at once. The situations for Grunt-whistle (GW), Down-up (DU), Nod-swimming (NS), and Turn-back-of-head (TBH) have already been discussed.

The major stages in the process of pairing are summarized in Table 1. This very complex form of social courtship has evolved as a mechanism permitting choice of mates in wintering flocks of ducks, where disputes between individuals may be expected to be inevitable. The male displays seem to serve a number of functions: (1) they indicate the male's readiness to pair; (2) they indicate which female has been selected; (3) some probably serve as threats to competing males; (4) some may inhibit the female's aggressiveness. In general, social courtship probably functions to channel male hostility into "harmless" activities, thus avoiding constant strife between males while the female is making her choice.

B. Radiation studies.

In April 1966, a shipment of male Teal was received from California. These birds had been captured from the wild in February and held for us in California. Unfortunately covered pens were not available and the birds had to be feather-clipped.

Films of the courtship behavior of some of these birds were made in early May 1966, but this was difficult since the birds were very timid in their new quarters. On May 18, an LD₅₀ experiment was carried out, involving four groups of eight birds, which received 400r, 600r, 800r, and 1000r. The LD₅₀₋₃₀ was determined to be 485r. (Results are reported in full in Appendix A). The 400r and 600r groups were returned to one of the filming pens and several attempts were made to obtain films of those which survived. In all cases, the birds refused to respond to an introduced female, and no films of value were obtained. There are several possible reasons for this absence of courtship behavior after irradiation (confinement in small pens, effects of feather-clipping, frequent disturbance to check for dead birds, etc.). At this stage we cannot say whether the lack of courtship activity was a result of the treatment. These birds will grow their new flight feathers this summer and we will be able to study their courtship behavior in spring 1967.

FIG. 3. SUMMARY DIAGRAM ILLUSTRATING THE SITUATIONS IN WHICH DIFFERENT DISPLAYS ARE PERFORMED. (SEE TEXT FOR EXPLANATION).

<u>Female</u>	<u>Common responses of males</u>	
	<u>Activity</u>	<u>Displays</u>
Absent	Occasional hostile encounters; mild threats or pecking	Bill-up in hostile situations "Burps" in response to birds flying over pen Very rarely social courtship displays go off "in vacuo"
Released into pen	Alert; observe female	Burst of "Burps"
Female on land or edge of pond; nervous at first; shows no interest in males	(1) Approach female closely on land; increased hostility toward other males, with threats and chasing (2) Hostility toward female (threats and fights bill-to-bill) (3) Stand lateral to female on land or edge of pond (4) Enter water and give displays to female on pond edge	Bill-up Down-up occasionally Bill-up occasionally Lateral Dip, Shake + Bridling, Shake + Belly-preen Grunt-whistle, Head-up-tail-up, Turn-toward-female, Nod-swim
Female enters water; may give Nod-swimming and quacks in response to male displays	A. Swim around very actively (1) directing displays to female (2) swimming off other males (3) avoiding other males B. Stand on pond-edge giving displays to female C. Perform flights	(1) Bill-up and Down-up when other males close (2) Grunt-whistle sequences and Turn-back-of-head when undisturbed by other males close (3) Wing-flap, Shake (4) Multi-syllabled calls Nod-swimming frequently Shake + Bridling Jump-flight Hovering-flight
Female performs "Inciting", showing preference for one male	(1) Hostility between males increases; vigorous chasing and fighting (2) Continue to direct displays to female (3) Preferred male stays close to female	Grunt-whistle etc. Bridling, Burps Bill-down when female faces him
Female alone with preferred male	Preferred male follows female closely	Lateral Dip, Preen-behind-wing Pre-copulatory Pumping (occasionally by female also); copulation only very rarely follows

Table 1. Outline of the major stages in the process of pairing as observed in the experimental pens.

SUBPROJECT TWO

EFFECTS OF IONIZING RADIATION ON TERRITORIAL BEHAVIOR IN THE SHOVELER, ANAS CLYPEATA

A. Study of dominance relations in captive flocks outside the breeding season.

An important phase of the study of territorial behavior in the breeding pens is the selection of the eight pairs of Shovelers to be used. This study of dominance relations in the captive groups during the winter months has provided important background information on the individuals selected.

As in the previous year, four groups of birds were kept visually isolated throughout the winter of 1965-66. This year, the birds were all yearlings. Regular observations were made on each group through one-way plastic windows in a dividing wall of the wintering house at Carlos Avery Game Research Center.

Dominance hierarchies again developed in the males of each group (Table 2). These were similar to the "peck-dominance" type described by Masure and Allee (1934a) in pigeons, where pecking and other hostile behavior is "bi-directional" and dominance is usually gained by the bird which wins most encounters. In addition, hierarchies were found in the females of each group. These were more rigid than those of the males, and they appeared to be closer to the "peck-right" type of hierarchy described by Schjelderup-Ebbe (1922) in domestic fowl (Table 3).

Reversals of rank were frequent in the male hierarchies. Each year there were several examples of subordinate males gaining dominance over their superiors. These reversals frequently occurred during the pair-formation period of early March and April (Fig. 4). At times, pecking "triangles" developed, but these ultimately tended to resolve into linear dominance relationships, especially during the pairing period.

In most cases, from December to early March, females were equal to or greater than males in level of aggressiveness (Fig. 5), and in general females were dominant over males during these months. In early March, pair-formation activities began to reach high intensity and the males gradually became more aggressive. By April, the males were responsible for almost all hostility and in some groups they had become dominant over the females (Table 4). Similar reversal of the dominant sex during the pairing season is known in a number of other birds (e.g. Snow Goose, Jenkins, 1944; Shell Parakeet, Masure and Allee, 1934b; House Finch, Thompson, 1960).

Competition for positions on the cement edge of the pond was a major cause of hostility, since crowding was most frequent there. The birds also competed vigorously for sleeping places in patches of sunlight on the ground near the windows (probably in response to the heat).

In October 1965, an attempt was made to determine dominance relations between males by pairing them in a small cage after the methods of Guhl (1962). The tests were unsuccessful, none of the birds showing any hostility. Such tests would require a larger cage and would probably be most effective during the mid-winter pairing season. No experiments of this kind were carried out during winter since the repeated capturing of individuals would have had a disturbing and weakening effect on the whole flock.

Table 2. Results of hostile encounters between male Shovelers (December 16, 1965 to April 29, 1966). Figures represent total encounters won by males in vertical columns over males in horizontal rows.

Group I (25 3/4 hours of observation)

<u>Male No.</u>	<u>67</u>	<u>66</u>	<u>61</u>	<u>68</u>	<u>Total</u>
67	-	9	13(1)	28	50(1)
66		-	9	8	17
61		1	-	18	19
68	8(1)	1	0(2)	-	8(3)

Group II (19 3/4 hours of observation)

<u>Male No.</u>	<u>40</u>	<u>33</u>	<u>60</u>	<u>51</u>	<u>Total</u>
40*	-	4(2)	6(1)	8	18(3)
33		-	10	8	18
60			-	5(1)	5(1)
51				-	0

Group III (25 hours of observation)

<u>Male No.</u>	<u>41</u>	<u>00</u>	<u>18</u>	<u>47</u>	<u>Total</u>
41	-	33(3)	58(2)	10(1)	101(6)
00	0(3)	-	6	34(2)	40(5)
18	11	11(2)	-	19(2)	41(4)
47	28(1)	1(3)	0(1)	-	29(5)

Group IV (19 hours of observation)

<u>Male No.</u>	<u>76</u>	<u>78</u>	<u>71</u>	<u>Total</u>
76	-	7(1)	3	10(1)
78	10	-	11	21
71**			-	0

() indicates hostile encounters with uncertain outcome

* Male 40 died in January, 1966, male 33 became No. 1 male.

** Male 71 died in March, 1966.

Table 3. Results of hostile encounters between female Shovelers
(December 16, 1965 to April 29, 1966).

Group I (25 3/4 hours of observation)							
Female No.	<u>58</u>	<u>54</u>	<u>51</u>	<u>56</u>	<u>45</u>	<u>50</u>	<u>Total</u>
58	-	12	6(1)	11	7	14	50(1)
54		-	14	5	6	11(1)	36(1)
51		1	-	9	9	20(1)	39(1)
56		2		-	3	10	15
45					-	12	12
50	0(1)	0(2)		0(2)	0(1)		0(6)
Group II (19 3/4 hours of observation)							
Female No.	<u>18</u>	<u>41</u>	<u>17</u>	<u>00</u>	<u>07</u>		<u>Total</u>
18	-	18(1)	7(1)	5(1)	15(1)		45(4)
41		-	6	3	6		15
17			-		10		10
00*				-	4		4
07**	0(1)	0(1)			-		0(2)
Group III (25 hours of observation)							
Female No.	<u>71</u>	<u>69</u>	<u>66</u>	<u>78</u>	<u>67</u>	<u>68</u>	<u>Total</u>
71***	-	5(4)	15	11(1)	31	9	71(5)
69		-	12	2	19	8	41
66	0(1)	1(2)	-	14(1)	14(1)	21	50(5)
78	0(1)	1	2	-	10	12(2)	25(3)
67		0(3)	0(2)		-	8	8(5)
68			0(1)			-	0(1)
Group IV (19 hours of observation)							
Female No.	<u>48</u>	<u>60</u>	<u>61</u>	<u>46</u>			<u>Total</u>
48	-	11(1)	12	1			24(1)
60	2(1)	-	17	13			32(1)
61	0(1)		-	10(1)			10(2)
46	29(1)	6(3)	8	-			43(4)

() indicates hostile encounters with uncertain outcome.

*Female 00 died January, 1966.

** Female 07 died February, 1966.

***Female 71 accidentally killed March, 1966; Female 69 became No. 1 Female

Fig. 4. Examples of reversals in dominance between males during observations in winter and early spring. "X" indicates the male observed to be dominant on a certain day.

1965						
♂						
13				X	XXX	
14			X		XXXXXX	XX
5					XXXX X X	
35		X X		X	XX	XX
1965-66						
♂						
68	XX			XXX		
67				X X X	X	
00					XXX	
18	X X XX		XX X			
18			XXX X			
41	XXX XX				X X XXX	
41					XXX	
47	XXXXX	X X	X	X	X	
76	XXXX					X
78				X	X	
Month:	December	January	February	March	April	May

Fig. 5 . TOTAL NUMBERS OF HOSTILE ENCOUNTERS PER BIRD PER HOUR OF OBSERVATION, SHOWING RISE IN MALE AGGRESSIVENESS IN MARCH AND APRIL AND CORRESPONDING DECREASE IN FEMALE AGGRESSION IN APRIL.

HOSTILE ENCOUNTERS WITH MALES

HOSTILE ENCOUNTERS WITH FEMALES

Table 4. Dominance relations between sexes during winter and early spring observations. Each figure represents the total number of attacks by birds of one sex on the other sex.

<u>1965</u>	<u>Dom. Sex</u>	<u>Dec.</u>	<u>Jan.</u>	<u>Feb.</u>	<u>Mar.</u>	<u>Apr.</u>	<u>May</u>
Group I	♂					74	18
	♀					1	0
Group II	♂					7	1
	♀					3	2
Group III	♂			2	9	10	4
	♀			5	12	7	2
Group IV	♂			23	7	7	9
	♀			17	0	0	0
Total	♂			25	16	98	32
	♀			22	12	11	4
<u>1965-66</u>							
Group I	♂	19		0	49*	8	
	♀	50		2	132**	9	
Group II	♂		42	10		0	
	♀		38	18		0	
Group III	♂		1	1		38	
	♀		84	164		3	
Group IV	♂		0	0	10	20	
	♀		82		31	11	
Total	♂	19	43	11	59	66	
	♀	50	204	184	163	23	

*Males dominated 27 times before March 15; 22 times after March 15.

**Females dominated 108 times before March 15; 24 times after March 15.

The Shovelers were moved to four holding pens at Cedar Creek on April 27 and observations were continued for several days to check the strength of the suspected pair-bonds. On May 3, the dominant pair was selected from each group and these four pairs were introduced into breeding pen I. Four subordinate pairs were introduced into pen II. The levels of aggressiveness of individuals changed during the territorial period (May-June) and the ratings established for birds in the wintering groups bore little relation to their aggressiveness when holding territories. This result was similar to that obtained in 1964-65.

Conclusions. The males in each of the eight groups of captive Shovelers observed in the Carlos Avery wintering house in 1964-65 and 1965-66 established hierarchies of the "peck-dominance" type. The hierarchies were unstable as illustrated by the observation of rank reversals in five groups. In 1965-66, linear dominance hierarchies formed among the females in three of four groups and a non-linear hierarchy formed in the other group.

Females were either equal to males in aggressiveness (1964-65) or were more aggressive than males (1965-66) until the time of intense pair-formation activity in late March and early April. Male aggressiveness began to increase in March and by April males were the most aggressive sex in six of the eight groups.

Competition for preferred space in the wintering house was a major factor in creating hostility between individuals.

Knowledge of a male's level of aggressiveness in his winter group did not give an indication of his subsequent level of aggressiveness in the breeding pens.

B. Study of territorial behavior.

The behavior of the eight pairs of Shoveler introduced to the breeding pens on May 3 followed a pattern similar to that observed in 1965. In 1966, however, all birds were yearlings, and this probably accounted for the longer period taken to establish well defined territories, the later initiation of laying, and the failure of two females to breed. Despite these differences from the behavior of adult birds, as found in 1965, the territorial behavior was very similar. Total numbers of chases observed during the first four hours after dawn were comparable in the two years (Table 5). Most males were successful in establishing territories but, as in 1965, there was one instance of a dominated pair which was subordinate in all parts of the pen.

To obtain representative samples of the behavior of these eight pairs, observations were made on two of every three mornings, for a period of four hours (May 5 - June 13) or three hours (June 15 - June 25). Particular attention was paid to the location of birds (plotted every 10 minutes) and the location, nature, and result of hostile encounters. The results have not been fully analysed as yet, but some preliminary conclusions are reported below.

C. Behavior of two irradiated males.

By May 23, the arrangement of territories had become stable in both pens. On May 24, the males from both pens were captured and transported to the University's Gamma Irradiation Facility in Minneapolis. One bird from each pen received a dose of 400r while the other males were confined in

boxes for a similar period (12 minutes 12 seconds). (The LD₅₀₋₃₀ for Shovelers is about 894r). All birds were released in their pens 1 3/4 hours after capture. Within a few minutes all had returned to their respective territories and were behaving as though nothing had happened.

Systematic observations on the breeding pens were continued through June 28, by which time the level of male hostility had dropped sharply, most territories had broken down completely, the males were behaving sociably and had begun to molt into the eclipse plumage. Ducklings began to hatch on June 19, and by June 28 five of the six clutches laid had hatched.

In general our observations failed to show any striking change in the behavior of the two irradiated males. One copulated, in an apparently normal way, on the morning after irradiation. Both continued to occupy essentially the same areas as before irradiation, showing no obvious differences in feeding or sleeping activities (but these were not measured precisely). The responses of these males to their mates appeared normal. Finally the form and frequency of their chasing activity toward other birds was much the same as it had been before irradiation (Table 5).

Comparison of maps plotting locations of these males before and after irradiation suggests a possible minor change in the area occupied by male 6 on the day after irradiation (Fig. 6). While both males confined most of their movements to the established territory, male 6 showed a slight tendency to move out of it from time to time on the first day. On subsequent days, he did not do this, possibly as a result of being chased back to his own area by other birds. Male 6 was chased frequently on May 25 and 26, but there was no increase in the amount of chasing directed at male 1 (Table 6).

These changes in area occupied and in chasing activity are minor, however, and on the present evidence it is not possible to conclude that they were a result of irradiation. It is possible that further analysis of the data will reveal behavioral changes which can be related to the treatment. At this time, we can state only that the irradiation appeared to have remarkably little effect on the territorial behavior of these two individuals.

Lethal dose experiment. On October 20, 1965 an experiment was carried out to determine the LD₅₀₋₃₀ for Shovelers. Four groups of eight birds were exposed to 500r, 700r, 900r, and 1100r in the University's Gamma Irradiation Facility. The LD₅₀₋₃₀ for these birds was about 894r. (For details of this experiment see Appendix A).

Table 5. Chases by male Shovelers directed at other males during May and June 1966, expressed as chases per hour. Males 1 and 6 received 400r on May 24. Rates for 1965 are based on observations for the first 4 hours after dawn on May 14, May 19, June 2, June 9 and June 16.

[illegible]

May 22 and 23, 1966. (8 hours observation)

May 25 and 26, 1966. (8 hours observation)

FIG. 6 . ACTIVITIES OF TWO MALE SHOVELERS ON THE TWO DAYS BEFORE IRRADIATION (TOP) AND THE TWO DAYS AFTER IRRADIATION (BOTTOM). THESE BIRDS RECEIVED 400 R ON MAY 24. THEIR MATES WERE IN THE LAYING PHASE AT THIS TIME. (SEE ALSO FIG. 7)

- LOCATION OF BIRD ⊙ SLEEPING PLACE + COPULATION
- FEMALE IN NESTING COVER ▣ NEST.

June 6 and 7, 1966. (8 hours observation)

June 21 and 22, 1966. (6 hours observation)

FIG. 7 . ACTIVITIES OF THE TWO IRRADIATED MALES TWO WEEKS AFTER IRRADIATION (TOP) AND FOUR WEEKS AFTER IRRADIATION (BOTTOM). (SEE FIG. 6 .) BY JUNE 21 AND 22 TERRITORIES HAD BEGUN TO BREAK DOWN. A SIMILAR PATTERN WAS SHOWN BY NON-IRRADIATED MALES.

Table 6. Rate at which male Shovelers were chased by other males, May and June 1966.

Date and observation periods	Pen I				Pen II			
	0	1	2	3	4	5	6	7
May 4-5 (6 hrs)	3.8	1.7	0.2	2.5	0	1.5	2.2	1.5
May 7-8 (8 hrs)	1.0	3.2	0	1.2	1.6	1.9	4.6	0
May 10-11 (8 hrs)	2.2	3.6	0.4	1.0	1.6	2.5	5.6	0.4
May 13-14 (8 hrs)	2.2	1.0	1.0	5.6	0.5	4.0	7.8	0.4
May 16-17 (8 hrs)	0.9	2.2	0.6	6.2	1.8	7.4	1.5	1.6
May 19-20 (8 hrs)	0.1	1.5	0.8	10.8	3.9	8.5	1.5	2.1
May 22-23 (8 hrs)	0.5	0.6	0.9	5.2	2.6	9.8	1.4	0.5
May 24 Irradiation		*					*	
May 25-26 (8 hrs)	0	0.6	0.2	6.0	1.1	2.5	6.1	0.6
May 28-29 (8 hrs)	0.5	1.4	0	4.9	0.8	5.8	2.2	2.0
May 31-June 1 (8 hrs)	0.3	0.5	0.2	6.0	0.7	2.8	1.7	1.3
June 3-4 (6 hrs)	0.3	1.7	0.3	5.8	0.3	6.0	5.3	3.5
June 6-7 (8 hrs)	0.4	1.8	0.5	4.2	0.4	5.9	14.2	1.8
June 9-10 (8 hrs)	0.2	2.4	0.6	2.1	0.4	3.5	1.5	1.1
June 12-13 (8 hrs)	0.2	1.5	0.2	3.6	0.5	3.2	3.8	5.5
June 15-16 (6 hrs)	0	1.0	1.7	3.8	0.8	4.8	4.5	3.3
June 18-19 (6 hrs)	0.3	2.5	0.3	5.0	0	1.7	6.3	0.7
June 21-22 (6 hrs)	0.3	1.2	0.3	1.3	0	0.3	7.0	0.3
June 24-25 (6 hrs)	0.3	0.5	0.2	0.8	0	0	2.8	0
June 27-28 (2.1/2 hrs)	0	0	0	0	0	0	0	0

SUBPROJECT THREE

EFFECTS OF IONIZING RADIATION ON RENESTING IN THE BLUE-WINGED TEAL, ANAS DISCORS

Field Studies

Since the last progress report work on this subproject included completion of field studies in 1965, analysis of data and modification of techniques during the winter, and initial field investigation this spring.

Summer, 1965

Twenty-three more Blue-winged Teal nests were located after June 15, 1965 to give a total for the season of 275. This figure is less than that for the previous year (283) because 102 nests which were terminated when found in 1964 were included in order to then obtain an impression of total nesting activity. Since these nests yield no dynamic information on reproductive biology and present a biased picture of overall nest success, they were not included in 1965.

The increase in nesting in 1965 over 1964 is in contradiction to an apparent decrease in the number of breeding pairs counted. Breeding pair estimation is an acknowledged problem in waterfowl production studies, and the range of variability in such counts could well be the reason for this reversal. The size of the difference, however, and additional information bearing on the number of birds present indicate that the increase is real. Further data pertaining to this increase will be discussed below in connection with the number of Teal marked. The fates of the 275 nests are presented in Table 7. Again, as in 1964, an active skunk population caused most of the nest destruction. Though earlier studies (Kalmbach, 1937 and Hammond and Forward, 1956) concluded that careful intrusion of humans had little effect in increasing nest predation, the repeated visits required in this study to locate nests, trap the nesting hens, and to note the progress of the nests were almost certain to have some effect. The same is true of nest desertion, since most instances of desertion occurred either after the finding of the nest or the trapping of the hen on the nest. The 41 nests which hatched produced a total of 441 ducklings on an area of 403 acres.

Table 7. Fate of 1965 nests.

	Marked hen	Unmarked hen	Subtotal	Percentage*
Hatched	38 (7)	3	41	16
Deserted	14 (2)	44	58	22
Destroyed	86 (9)	77	163	62
Unknown	4	9	13	
Total	142 (18)	133	275	100

* Based on 262 nests of known fate
() Renests

Thirty more hens were individually marked after June 15 to give a total of 141 for the year. Of this number 123 were known to have nested at least once. This minimum number of breeding hens, when compared to the number of pairs counted, shows further the short-comings of the pair-count procedure. It appears that a count of all drakes, though theoretically erroneous, may give a more realistic estimate of the breeding population with the excess drakes off-setting the incompleteness of the count.

In addition to the 141 adult hens, 51 adult drakes were marked and banded and 44 juvenile Teal were banded by late summer (Table 8). Thirteen of the Teal color-marked in 1965, 11 adult hens and two juvenile hens, had been banded the year before on the study area. The return of 11 of the 61 adult hens marked in 1964 (18 percent) is comparable to the 14 percent homing rate found for Blue-winged Teal by Sowls (1955). Because the nests of homing ducks have been observed to be located close together in consecutive seasons just as are renests within the same season, these 11 hens and their nests were of particular interest. The 1965 nests of nine homing hens were located. The mean distance of these nests from the 1964 nests of the same hens was 459 feet with a range of 64 to 1406 feet. Other data were obtained on clutch size, nest site and vegetation, and loafing sites, but these have not yet been summarized.

Table 8. Teal captured in 1965.

Adult males		51
Adult females		141
with known nests	123	
banded in 1965	112	
banded in 1964	11	
without known nests	18	
banded in 1965	16	
banded in 1964	2	
Juveniles		44
male	17	
female	27	
Total		236

Eighteen of the 275 nests found in 1965 were known renests. Several other nests of marked hens were found but were terminated before these hens could be identified. In addition, some of the nests terminated early could have resulted in renests which were not recognized as such if the hen was not yet marked. Eighteen, then, is a minimum number of renests. This is eight percent of the maximum possible number of initial, terminated nests, and compares closely with Sowls' (1955) figure of six percent for Blue-winged Teal. A thorough analysis of nest initiation dates and the chronology of nest discoveries may yield a more accurate estimate of the extent of reneesting. Keith's (1961) and Gates' (1965) method of estimating the number of renests from the ratio of the number of nests found to the number of breeding pairs may have potential, but it is dependent on the before-mentioned

uncertain censuses of breeding pairs. This method, even when the maximum number of drakes is used as a pair estimate, indicates that nearly 90 percent of the nests are renests (though not necessarily made by 90 percent of the Teal).

Some of the parameters of the 18 renests of 1965 are presented in Table 9. In general it appears that there is no "renesting interval" (Sowls, 1955) until the clutch reaches seven or eight eggs, or perhaps two or three eggs less than what would have been a full clutch. With less than seven eggs most hens built what Brakhage (1965) calls a "continuation nest," that is, they continued to lay but in a new site. Though the data are limited they tend to show the renesting interval gradually lengthening as incubation of the initial nest progresses. The average number of eggs in full clutches shows the typical reduction from initial nests to renests. Thirty-nine percent of the renests hatched. This seems quite different from the overall rate of 16 percent but has not yet been tested statistically. The average distance between initial and renests is 639 feet, which is midway between the 480 feet recorded for Cinnamon Teal by Hunt and Anderson (1966) and the 810 feet recorded in Sowls' study. It is interesting that in both Sowls' study and this one the average distances between nests of homing birds was less than that of renesting birds. Changes in pair bonds and territories in association with renesting were also recorded but these qualitative data have not yet been fully analysed.

With the decrease in clutch size of two eggs per nest it would be of interest whether the number of young successfully brought to flying age dropped proportionately. Therefore brood censuses were conducted from the time of the first known hatching. Though 41 nests hatched only five broods were sighted due to the thick emergent cover, so this question has been left unanswered for the present.

Spring, 1966

The most significant point about this spring has undoubtedly been the weather. What began as an "early spring" in March reverted to cold and wet periods through April and into late May. A snow on May 11 covered the vegetation with a one inch blanket, and near-freezing temperatures occurred at night well into May. Teal and several other species of birds being studied in other projects on this area appear to have been greatly affected by this prolonged cold weather. Activities of Coot (Fulica americana) and Rails (Rallidae) as well as of Teal generally show delays of two to three weeks.

No Teal were seen on Dewey's Pasture until April 22 although they were present in the general area well before that date. The results of periodic pair counts are presented in Table 10 for all three years of this study, with lone drakes and pairs lumped in an overall estimate. These counts show that the chronology of Teal arrival is little different over the three years. The maximum count was also obtained at approximately the same time of each year. The counts also imply that the 1966 population is lower than that of recent years.

Table 9. Renests in 1965.

Identification Number	Stage of Termination of Initial Nest	Interval (days)	Number of Eggs in Renest	Fate	Distance from Initial Nest
1*	2 eggs	0	11	Hatched	234 feet
2*	3 "	18**	7***	Destroyed	0
3	5 "	0	10	Hatched	174
4	6 "	0	2***	Destroyed	236
5	7 "	5	10	Destroyed	1,788
6	8 "	5	9	Destroyed	725
7	8 "	15**	10	Hatched	120
8	9 "	6	2***	Deserted	388
9	10 "	2	10	Destroyed	134
10	1st of inc (12)	7	10	Hatched	247
11	3rd " " (12)	13	8	Destroyed	714
12	4th " " (10)	7	6***	Destroyed	281
13	incubating (10)	8	9	Hatched	51
14	" (11)	9	10	Destroyed	1,480
15	" (12)	6	7	Destroyed	215
16	" (11)	-	10	Hatched	627
17	" (13)	-	11	Hatched	2,223
18	" (12)	-	7***	Destroyed	1,870
Average	11.4		9.3	39% Hatched	639 feet

* - 3rd nest

** - possibly an intervening nest

*** - incomplete clutch

()--number of eggs

Table 10. Pair counts for the three years of this study.

Count number		1964	1965	1966
1	number date	6 April 11	37 April 20	0 April 11
2	number date	18 April 16	85 April 26	27 April 26
3	number date	28 April 20	87 May 3	65 May 4
4	number date	35 May 4	120 May 12	76 May 19
5	number date	116 May 13	145 May 31	72 June 5

Marking of Teal began on April 29 in 1966 with the birds being caught initially in bait traps and by night-lighting and later in nest traps. The results of these trapping operations are presented in Table 11 for weekly intervals starting with the date of the first capture. Captures from 1965, a year in which comparable methods and effort were used, are included in the table. The difference of 30 birds caught in the two years is almost entirely attributable to the catch of the first two weeks (difference of 25). Though trapping began at the same general time in both years there was a greater initial response in 1965. This may be a reflection of the earlier movement of Teal onto the smaller marshes in the milder 1965 spring.

Table 11. Number of Teal marked per week interval in 1965 and 1966.

	Interval by weeks							Total
	1*	2	3	4	5	6	7	
1965	24	25	10	33	25	10	15	142
1966	6	18	23	15	16	21	13	112

*Began on April 26, 1965 and April 29, 1966.

Ten of the marked hens banded in 1965 (seven as adults and three as juveniles) have returned to this nesting area. Seven other hens marked in 1965 have been sighted and identified but not caught. This homing rate of 14 hens of the 141 marked in 1965 (ten percent) is below the rate of 18 percent for the previous year and may be related to the apparent overall population decrease or may just reflect the fact that not all nesting hens have been found. Nests of nine of the 14 returning adult hens have been found and will be analysed as were those found in 1965.

Nasal tabs were still present on 13 of the 14 returning adult hens.

Teal homing in 1965 were marked in 1964 with nasal discs and of those 11 hens only three retained their discs until the following spring, indicating that nasal tabs have better retention than discs. In addition, it was possible to identify all 13 tabbed hens prior to their capture while none of the three discs retained any identifying number.

Up to June 15, 1966, 127 nests had been found, approximately half of the number found by that date in 1965. Nest initiation figures for all three years are presented in Table 12. These data indicate that nesting by the 1966 population was about 2.5 weeks later than in previous years. They also show a marked reduction in total nests for 1966 which could be just a reflection of the late start, or actually due to a lower Teal population on the area.

Table 12. Number of nests begun per one-week intervals in the three years of this study.

Year	Interval by weeks.							Total
	1*	2	3	4	5	6	7	
1964	23	42	32	22	29	12	12	172
1965	44	75	46	27	35	25	7	259
1966	2	7	20	40	34	16	8	127

*Began on May 8, 1964, May 1, 1965, and April 28, 1966

The behavior of the nesting hens this year also seems different from that previously observed in this or other studies of Blue-winged Teal (Bennett, 1938; Glover, 1956). The hens arrive at the nest earlier, stay a shorter time, are less prone to flush during a disturbance, but are more likely to desert if they are flushed. This last point can be seen in the listing of nest fates in Table 13. Twenty-eight percent of the hens deserted their nests when they were found as compared to only 22 percent which deserted for all reasons in 1965.

Table 13. Fates of 1966 nests as of June 15, 1966.

	Marked hens	Unmarked hens
Still active	30 (4)	2
Destroyed	32 (3)	16
Deserted	6	5
Deserted when found	3	33

() Renests

Seven of the 127 nests found to date are known renests of four marked hens. Two hens have renested once, one has renested twice, and one three times. Of the 61 initial nests of known marked hens 35 had terminated prior to June 15 making these hens potential renesters. The four hens which have renested represent 11 percent realization of this potential. Hunt and Anderson (1966), working with Cinnamon Teal, found that six of 48 (13 percent) marked hens renested. Their study, like the present one, used actual observations of individually marked birds rather than estimates from counts of general populations.

Field studies on this subproject will terminate at the close of this nesting season (see Renewal Proposal).

SUBPROJECT FOUR

BIOLOGICAL, BEHAVIORAL AND PHYSICAL FACTORS AFFECTING HOME RANGES OF SNOWSHOE HARES (LEPUS AMERICANUS), RACCOONS (PROCYON LOTOR) AND WHITE-TAILED DEER (ODOCOILEUS VIRGINIANUS) UNDER NATURAL CONDITIONS.

Studies began on this subproject in 1964. To date a total of 17 deer, 64 raccoon and 15 snowshoe hares have been radio-tagged and studied for varying periods. Field investigations are currently in progress on raccoons and hares and deer studies will again be initiated in fall, 1966. Data on movements, behavior, mortality, population dynamics, etc., of all radio-tagged animals are currently being analyzed and numerous manuscripts have been prepared (See PUBLICATIONS section of the PROGRESS REPORT). Rather than include entire papers with graphs and tables in this PROGRESS REPORT, only the abstracts or summaries of completed but unpublished papers will be presented.

Results of these investigations have led to the study of theoretical aspects of animal movements. Heezen and Tester (In press) evaluated animal location data obtained by triangulation by analyzing field data on deer movements and by computer simulation using random plots. Each plot was assumed to represent 60 minutes activity of a deer traveling in a random direction for one minute at a speed between 0 and 3.5 miles per hour, stopping at the end of one minute, turning a new random direction and again traveling for one minute at a speed between 0 and 3.5 miles per hour, etc. The abstract of this paper is given below.

Tester and Siniff (1965) examined the development of the center of activity and the cumulative mean activity radius of an increasing amount of location data for adult male raccoon 603. They also studied the intensity of use of this individual's home range by analyzing the mathematical distribution of the point locations within it; and they considered the effect of sampling interval on the calculated total-distance traveled and area used. Mech (1965a) attempted to critically evaluate the concept of home range, including the definitions, methods of gathering data, and methods of calculation and expression.

Heezen, K. L. and J. R. Tester. Evaluation of animal location data obtained by triangulation. J. Wildl. Mgmt. In Press. (COO-1332-16).

ABSTRACT

Four parameters out of the five investigated were found useful for studying white-tailed deer (Odocoileus virginianus) movements by triangulation with an automatic radio-tracking system. These were total area, greatest linear dimension, mean activity radius and distribution of activity radii, and appearance of the map. Random plots, which simulated deer movements, were used to determine the effects of varying the location of the animal's range in relation to the triangulation stations. Results show an increase in size of range and a loss in accuracy of location as the plots were moved out. An "hourglass-shaped" area of about 3,300 acres is considered to be within acceptable accuracy with a 0.5 mile base line and a $\pm 0.5^\circ$ resolution. Point locations were obtained at 1-minute intervals for selected time periods for three deer. These data were then sampled at intervals of 2, 3, 4, 5, 6, 10, 15, 30, and 60 minutes. Values for total area and greatest dimension decreased and the mean activity radius increased as the sampling interval became longer. A sufficient number of point locations can be maintained by using a short sampling interval or long observation period.

Raccoon studies

Because of the mass of data collected on raccoons by the automatic radio tracking system, we have temporarily decreased the scope of our field studies and are currently concentrating on data analysis and preparation of manuscripts. This will provide the basis for future ecological field investigations and will serve as baseline information for evaluating radiation effects.

A classified bibliography on the raccoon based on approximately 500 references is being prepared for publication in collaboration with Dr. Glen C. Sanderson of the Illinois Natural History Survey.

Data for approximately a one-year period on seasonal weight changes, mortality and population dynamics of the raccoons on the CCNHA are being analyzed for publication. A total of 55 animals from this population were radio tagged during the study period and weights were obtained on these animals whenever they were recaptured. Post-mortem examinations were conducted by the Diagnostic Laboratories of the University of Minnesota College of Veterinary Medicine. In addition, data for these same 55 raccoons are being examined to determine the extent of home range, the relative intensity of use of habitat and seasonal changes in these parameters. An effort is being made to have this and the preceding analysis completed by 15 October 1966.

A study of fall daytime resting habits of raccoons, prior to the period of winter dormancy, was completed and the manuscript is in press (Mech, Tester, and Warner, 1966). The abstract of this paper is given below.

Because the radio tracking system provides nearly continuous data on locations of tagged animals, we have attempted to develop sampling procedures to aid in data reduction. Sampling at selected time intervals from the daily record or choosing certain blocks of days from monthly or seasonal records introduces the possibility of "missing" important movements or activities. One attempt to evaluate sampling will be based on a detailed study of movements of one young male raccoon for 135 days. A report on the baseline study has been submitted for publication and the abstract is presented below (Turkowski and Mech, Submitted).

An analysis is now in progress of daily resting sites of 6 male and 8 female radio-tagged raccoons studied during the spring, summer, and fall of 1965. A portable radio receiver was used to locate the sleeping raccoons during the day whenever possible. A total of 165 sites were found; 122 were located in swamp habitat, 32 in den trees and 11 in tree nests built by squirrels or birds. Movements of each raccoon prior to its selection of a particular resting site were plotted on base maps. The raccoons were classified into two general types according to their resting site preferences: (1) raccoons that selected den trees, swamps and/or open tree nests, and (2) raccoons that selected swamps almost exclusively. Seven raccoons were found 15 or more times in the field. Of these 4 were classified as swamp resters while 3 chose den trees and tree nests as well as swamps. The major focus of this study was to determine the causes for the differential selectivity of resting site types.

Tree nests were not used as resting sites after July 21, 1965. Possibly raccoons were searching these structures for eggs, young birds or squirrels which were only available in spring and early summer, and the use of the nests as resting sites was a secondarily acquired habit.

The raccoons were generally extremely difficult to approach when resting in the swamps even when using silent stalking methods. It was virtually impossible to find the exact bedding location of an individual that had been approached more than two or three times because the animal would usually move away from the observer. Subjectively, it appears that raccoons slept more deeply and thus could be approached more easily when they first left their winter dens in the spring than later in the study.

Twenty-four sightings were made of raccoons at or near swamp resting sites. These bedding sites varied from a simple, partially submerged depression in the bog substrate or a matted down hummock surrounded by pools of water, to a pocket-like configuration of roots 3 to 4 feet above the surface in an up-turned stump. Raccoons observed at these sites appeared to be sleeping soundly with eyes closed, completely motionless except for breathing movements and an occasional reflexive twitch of the ear. Individuals that awakened after the observer arrived at the rest site would leave the bed in a very secretive manner, moving through the swamp noiselessly, and with slow, deliberate steps. If their position had not been known initially they probably would never have been detected. The escaping animals traveled distances of 40 to 1800 feet (average 756.4 feet) before settling in another resting site. Of the 795 daytime rests determined by the tracking system, there were only 14 instances where shifting occurred naturally. These shifts involved distances of 160 to 2520 feet (average 825.7).

On 11 occasions raccoons were sighted in tree nests. They appeared to be undisturbed when approached for observation. On several occasions near-by trees were climbed to view the resting raccoons. Despite this disturbance they all appeared to be sleeping soundly when observed, but it was impossible to determine whether the animals were intentionally remaining motionless or whether they were actually asleep. Probably they were "freezing" to avoid detection. This represents a distinctly different behavior from swamp resting where intrusion always resulted in escape behavior. The reaction of a coon resting in a den tree to an intruder was not observed. Presumably this would be similar to the behavior exhibited in the tree nest.

Further analysis is planned of the distribution of rest sites in relation to habitat types in the home range.

During the eight months of the spring, summer, and fall of 1965 five reproductive female raccoons and eight young were monitored. Fixes were taken from film records hourly during non-movement periods and at 15-minute intervals during periods of movements. One female (No. 608) was already tagged before her spring travels began on April 2. Two others were tagged by April 26. Between May 12 and May 18, all three had selected litter trees in which their young were born, and to which they returned each daytime rest period. On May 26, another female also staying with young in a den tree was tagged. Between May 8 and June 30, all females except 608 had apparently lost their young. A manuscript describing an incidence of abandonment of young has been submitted to the Journal of Mammalogy and the abstract is presented below (Schneider, Mech and Tester, Submitted).

Raccoon 608 and her young first left the litter tree together on July 16 when the yet untagged young were judged to be 60 days old. Raccoon 608's radio expired on July 23. On August 4, a new female, No. 635 was tagged and six days later her nest on a hummock in a swamp was found. Three of five young (who were a month younger than 608's) were then fitted with transmitters. On August 28, 36 days after 608's radio had stopped transmitting, a young male of her litter was tagged. On September 3, after 39 days of silence, the radio on 608 began functioning (reason for mal-function unknown). By September 27, the remaining two young of 635 had been tagged. By October 28, two more of 608's young were radio-tagged. A fourth cub of 608 was found in a den tree and was radio-tagged after November 26, the date of the first snowfall. By this time all the study animals had ceased normal daily movement and had entered the period of winter dormancy.

During this study, approximately 20,000 fixes were accumulated in the 700 raccoon-days of the 13 animals. Often more than 20 fixes were obtained on a raccoon during one night's movement. Individual beds were field-located nearly each day for 608 and her young, and less often for other animals. Data are now being analyzed with reference to daily movement periods, movement areas, bed types, usage intensity of habitat types, and intrafamily relationships.

All females except 635 selected hollow trees for parturition. Previously, at least two of the females usually slept in the swamp beds; 608 had heretofore used either hollow trees or squirrel nests. After loss of their young, two females returned to sleeping in swamp beds. Movement areas of the adults varied from 1.0 to 2.5 miles in diameter, and the young stayed within the area used by their mother. The movement periods of all individuals were approximately 12 hours long, most of which was during darkness. The young of each litter began to move with the female at two months; after four months they frequently travelled and slept alone, with all permutations of female-young, young-young, and remaining alone, occurring.

Raccoon 608 and her litter denned in the same hollow tree for the winter. Except for two cubs separated from the family by trapping, 635 and her litter selected hollow trees close together in mixed swamp-upland habitat. The two estranged young denned in adjoining hollow trees distant from the rest of the family, but later, during mild weather, they returned to the family group.

Despite information being incomplete for any one raccoon during the entire study, data were obtained on all stages of warm weather reproductive activity. For example, Raccoon 608 and her cubs were not transmitting during the first month of her young's movements, but 635's young were tagged during the equivalent phase.

Mech, L. D., J. R. Tester and D. W. Warner. 1966. Fall daytime resting habits of raccoons as determined by telemetry. J. Mamm. In press. (COO-1332-13).

ABSTRACT

The locations of 173 daytime resting sites of seven raccoons (Procyon lotor) in east-central Minnesota were studied during September through November 1964. An automatic radio-tracking system was the main method employed to locate animals, although field checks with a portable receiver also provided data. Persistent field checks apparently disturbed one of the animals. Distributions of resting sites of four of the animals are illustrated, described, and analyzed; all individuals generally shifted resting sites from day to day, but each used certain areas more frequently than others. Ground beds in cattail marshes and alder and cedar swamps were used almost exclusively as resting sites. Some individuals shifted resting sites as much as a mile from one day to the next. No apparent patterns or consistencies among individuals were found in the frequency distributions of distances between consecutive resting sites, or of activity radii of the sites. Evidence is presented indicating that three individuals using the same general area seemed to maintain a certain minimum distance among the resting sites chosen by each on any given day.

Knowledge about the life history of any mammal is incomplete without information concerning its resting habits. However, until the advent of modern investigational techniques, it had been difficult to obtain such information. For raccoons, literature on the subject is limited to descriptions of the resting sites (Bergtold, 1925; Linsdale, 1928; Giles, 1942; Steuwer, 1943; Twitchell and Dill, 1949; Cabalka, 1952; Dorney, 1954). Ellis (1964) radio-tracked seven raccoons in Illinois but did not report on the distribution of daytime resting sites. No one seems to have answered the question (or even to have posed it) of whether raccoons use the same resting site each day, choose several locations and use them regularly,

or rest in a new site each day. Cabalka (1952:16) stated that "the resting sites used in the fall seemed temporary because raccoons were seldom found in the same resting places on consecutive days," but he obtained no information on the locations of individuals once they had left one of the temporary dens.

This paper reports primarily on the distributions of daily resting sites for four raccoons in east-central Minnesota during October and November 1964. Additional information is included on three other individuals studied only in November.

Turkowski, F. and L. D. Mech. An intensive analysis of the movements of a young male raccoon. Submitted to J. Mamm. (COO-1332-22).

ABSTRACT

Movements of a young male raccoon (Procyon lotor) were studied from February to August 1965 through the use of an automatic radio-tracking system. Data for 135 days were collected, and a total of 2,065 locations obtained. The study animal usually rested throughout the day in lowland, and shifted resting sites daily. He usually began his nightly activity within an hour before or after sunset and ceased within an hour before or after sunrise. His nightly movements varied both in extent and areas visited; one night he traveled at least 3 miles. He visited a certain cornfield on 87% of the nights, but seasonal shifts in intensity of areas used were evident. The greatest length of two-week activity ranges varied from 4,620 to 8,514 ft and that of the total range was 9,240 ft. The raccoon continued to visit new areas until about two weeks before the end of the study period (5.5 months). The intensity of use of the total activity range varied, with a few areas used intensively and most of the range used lightly.

Schneider, D. G., L. D. Mech and J. R. Tester. Changes in movement of a female raccoon after abandonment of young. Submitted to J. Mamm. (C00-1332-21).

ABSTRACT

Movements of a radio-tagged raccoon (Procyon lotor) with young were monitored by an automatic radio-tracking system. Upon capture in a steel trap 8 days after radio tagging, the raccoon chewed an attached "diazepam" tranquilizer tablet, and after release, did not return to her young. Her daily movement was divided into four phases. In Phase 1, from radio-tagging to steel-trap capture, her normal movement period was from sunset to 2 to 4 hours after sunrise; her movement area was 6500 x 3000 feet. She spent each daylight period in the litter tree. In Phase 2, the next 4 days, her movements were restricted to a small area and not more than two brief visits were made to the litter tree. Her movement period also was shortened, as had occurred briefly after the radio-tagging capture. In shortening her movement time she usually stopped earlier, but did not change her starting time. The young died near the end of this phase (4 to 5 days after abandonment). In Phase 3, from Phase 2 until 10 days after the steel-trap capture, she further contracted her area and shifted it such that there was no overlap with the Phase 2 area, and she resumed her normal movement period. By Phase 4, 30 through 38 days after the steel-trap capture, her movement area had approximated that of Phase 1. We postulate that the tranquilizer and/or injury were the primary causes of young abandonment.

White-tailed deer studies

The first deer to be studied in this project were radio-tagged in spring, 1964. Movements of these deer were analyzed, two manuscripts have been completed, one of these has been accepted and one is still being considered for publication. The abstract of Heezen and Tester (In press) was presented above and that for Heezen and Tester (Submitted) is given below.

Of the eleven deer radio-tagged in November and December, 1964, three males were selected for an intensive study of bedding habits. A thesis has been written on this subject and the abstract is presented below (Moulton, 1966).

Three of the radio-tagged deer were 6-month old, pen-raised fawns released on the study area in November, 1964. Their acclimation to natural habitat and reactions to an extremely adverse winter were studied by Tester and Moulton (1965).

No additional deer were radio tagged during the report period. The deer that were tagged during November and December 1964, were followed with portable receivers until the batteries went dead on the transmitters (May 4, May 28, June 4, June 16, and two on June 24, 1965). These deer left the CCNHA in April and moved to summering areas varying from 2 to 9 miles away, and were still present in these areas at the dates of the last checks.

Two of the radio-tagged deer were killed during the 1965 hunting season. A yearling buck was killed about 12 miles from its capture location and 16 miles from its "last" summer location May 28, 1965. A yearling doe was killed about 4 miles from its capture location and about 1.5 miles from the area where it was last heard on June 4, 1965.

A doe radio-tagged in 1964 was killed during the 1965 hunting season about 19 miles from its capture location. Two adult bucks that were ear tagged in February 1965 but did not have transmitters attached were killed during the 1966 hunting season. One was killed 1.5 miles from its capture location and the other about 65 miles away.

The winter movements, spring dispersal and kill location when known of nine deer in 1965 and 6 deer in 1964 are presently being analyzed and a manuscript is being prepared.

Heezen, K. L. and J. R. Tester. Observations on winter and spring movements of white-tailed deer in Minnesota obtained by radio-tracking. Submitted to J. Wildl. Mgmt. (COO-1332-17).

ABSTRACT

Data were collected from three white-tailed deer in east-central Minnesota by means of an automatic radio-tracking system. Comparisons of home range size were made among individual deer and between a winter and an early spring period using the following four parameters: (1) total area determined by connecting the most extreme perimeter points, (2) linear range or greatest dimension between the two most distant points, (3) mean activity radius and frequency distribution of activity radii and (4) appearance of the map as evaluated subjectively. Spring ranges were significantly larger than winter ranges and movements in spring were longer with less concentration of activity. The differences between winter and spring behavior are probably related to higher spring temperatures and the disappearance of snow.

Moulton, J. C. 1966. Movement and activity of three white-tailed deer during the winter of 1964-1965 in east-central Minnesota determined by telemetry. Univ. Minn., M.S. Thesis.

ABSTRACT

Activity patterns of three white-tailed deer (Odocoileus virginianus) 513, 515, and 516 were studied by the automatic radio-tracking system described by Cochran et al. (1965) in southeastern Minnesota during ten day sample periods during December 1964, January and February 1965. Radio transmitters similar to those described by Tester et al. (1964) were attached to the study deer, and the data automatically recorded on 16 mm film and later transferred to machine punch cards so that analysis could be carried out in part by a digital computer (Siniff and Tester, 1965). Deer locations were plotted by computer and activity classified as bedding, active, or unknown on the basis of signal characteristics. Activity factors investigated were areas of usage, number of bedding periods, lengths of bedding and active periods, percent bedding during periods of the day, daily activity rhythms, locations of bedding sites by habitats and reuse of beds. Areas used by deer 513 (a fawn doe) and 515 (an 8-point buck) were similar in size and were approximately one-third as large as the 1900 acre area used by deer 516 (another 8-point buck). The ranges of all three deer overlapped at one site. Both the December and January usage areas generally covered much of the winter area whereas the February use area, when snow was deep and heavily crusted, was more restricted. The number of bedding periods for each deer was usually at least one during the daytime and always at least one during the night, although the most common number of bedding periods was three during both periods. Little monthly variation occurred for any individual deer, but rather wide variation existed among the study deer. Mean durations of time that deer were continuously bedded were between 21 and 40 minutes for deer 515 and 516. Mean active periods were 21 to 40

minutes for deer 516 and 41 to 60 minutes for deer 515. Only slight individual variation existed for either deer during months, but a significant difference between the average length of the bedding periods and active periods existed between deer 515 and 516. Days were divided into four periods and the percent of time bedded in each period calculated. No significant difference was found among the average percent bedding for months and for periods of the day for any of the deer, although there was a highly significant difference among deer for the mean percent of daily bedding. Daily activity rhythms formed a pattern with a larger sample and indicated the times of major bedding and active periods. Generally, times of "most bedding" were approximately 0700, 1500, and 2100 for the study deer. Hours during which the study deer were especially active were 0200, 0800, 1100 and 1700 with maximum activeness at 1800. Most daytime and night bedding sites for all deer were in open or wooded lowlands. Upland woods were used as bedding sites more during night than daytime. Only one of the three deer made extensive use of fields as bedding habitat. The data indicate slight, if any, re-use of bedding sites.

In general, the data show no significant difference between months for any deer, but a highly significant difference between deer for almost every factor investigated.

Snowshoe hare studies

Data on snowshoe hare movements obtained in early 1964 have been analyzed and preliminary results were reported by Mech at the 1965 meeting of the American Society of Mammalogists. A detailed evaluation of daily activity rhythms of both snowshoe hares and cottontail rabbits has been accepted for publication; a copy of the summary of this paper is presented below (Mech, Heezen and Siniff, 1966).

Transmitters were put on 11 snowshoe hares (3 females and 8 males) during March and April, 1966. One female died two days after release. Two males died in traps when recaptured and foxes killed two males. Transmitters quit on two males after functioning for 32 and 53 days. Continuous information has been obtained on the other four animals for approximately 3 months.

Rabbit drive nets (Redport Net Co. Ltd., Bridport, Dorset, England) have been used with good success to recapture the hares so that batteries can be changed on the transmitters. As long as the transmitter is working, a hare can usually be recaptured in one or two hours by two men with the drive net.

Attempts have been made to find the young of the two radio-tagged females to determine the relationship of the female with her young. No young have as yet been found. This phase of the study will be continued throughout the summer.

Mech, L. D., K. L. Heezen and D. B. Siniff. 1966. Onset and cessation of activity in cottontail rabbits and snowshoe hares in relation to sunset and sunrise. Animal Behavior. In press. (C00-1332-15).

SUMMARY

Onset and cessation of activity were studied in a few cottontail rabbits (Sylvilagus floridanus) and snowshoe hare (Lepus americanus) through the use of an automatic radio-tracking system. These times varied greatly for the male cottontails studied in January but were more consistently correlated with sunrise-sunset times for the females in February. Contradictory conclusions of other workers are examined, and possible reasons for the contradictions given. Onset and cessation of activity in a female snowshoe hare studied in late winter and spring closely followed sunrise-sunset times, and there was a high correlation ($r = 0.95$) between seasonal changes in periods of daily inactivity and seasonal changes in length of daylight. Data suggest that cessation of activity may be stimulated by a certain light intensity rather than actual sunrise.

SUBPROJECT FIVE

EFFECTS OF IONIZING RADIATION ON HOME RANGE AND MOVEMENTS OF SNOWSHOE HARES AND RACCOONS.

Baseline studies on certain aspects of raccoon movements and behavior reported in Subproject 4 above have progressed to the point where we feel that we can evaluate effects of sub-lethal doses of irradiation. Although populations of raccoons have not been high enough for us to attempt to capture animals for an LD50 study, we believe that initial work can be based on the unpublished lethal dose experiments conducted by Dr. F. Golley, Savannah River Laboratory of Radiation Ecology.

On 16 June 1966 we exposed an adult male raccoon to a sub-lethal dose of 300 r from the cesium-137 source in the University's Gamma Irradiation Facility. Exposure was for 12 minutes at 25 r per minute.

This animal, Number 625, was first captured 29 April 1965 and was tracked for about one month when its transmitter stopped. It was recaptured 20 April 1966, a new transmitter was put on, and its movements were studied until it was recaptured for irradiation on 15 June. The raccoon was irradiated at about 1430 hours on 16 June and was released three hours later. Because of potential effects of irradiation on transistors, the radio transmitter was removed during the irradiation.

Preliminary analysis of the activities of raccoon 625 showed that it moved over approximately half of its total pre-irradiation home range of 3.5 miles by 1.5 miles the night of release and that on subsequent days it stayed within its pre-irradiation home range. We are continuing to monitor movements and activities of this animal and will analyze its behavior in detail as long as it survives.

Another adult male, raccoon 654, captured and monitored since 28 April 1966 is considered to be a "control" experimental animal and its behavior will be used as a baseline for evaluating the behavior of the irradiated raccoon. We believe that comparison of behavior of 625 before and after irradiation and comparison with control 654 will enable us to determine at least some effects of irradiation if manifested in behavior.

We intend to irradiate additional raccoons and several snowshoe hares during 1966 as discussed in the RENEWAL PROPOSAL.

PUBLICATIONS

- Heezen, K. L. and J. R. Tester. Evaluation of animal location data obtained by triangulation. J. Wildl. Mgmt. In press. (COO-1332-15)
- Heezen, K. L. and J. R. Tester. Observations on winter and spring movements of white-tailed deer in Minnesota obtained by radio-tracking. Submitted to J. Wildl. Mgmt. (COO-1332-17)
- McKinney, F. 1965. The displays of the American Green-winged Teal. Wilson Bull. 77(2):112-121. (COO-1332-2)
- McKinney, F. 1965. An analysis of pair-formation in Anas crecca carolinensis. (abstract) Bull. Ecol. Soc. Amer. 46(3):110-111. (COO-1332-7).
- Mech, L. David. 1965. Sodium pentobarbitol as an anesthetic for raccoons. J. Mamm. 46(2):343-344. (COO-1332-6)
- Mech, L. David. 1965. A critical evaluation of the concept of home range. (abstract) Bull. Ecol. Soc. Amer. 46(3):121. (COO-1332-9)
- Mech, L. David and Neil V. Anderson. 1965. Renal hypoplasia and compensatory hypertrophy in a raccoon. J. Mamm. 47(1):128-129. (COO-1332-10)
- Mech, L. D., K. L. Heezen and D. B. Siniff. 1966. Onset and cessation of activity in cottontail rabbits and snowshoe hares in relation to sunset and sunrise. Animal Behavior. In press. (COO-1332-15)
- Mech, L. David, V. B. Kuechle, D. W. Warner and J. R. Tester. 1965. A collar for attaching radio transmitters to rabbits, hares, and raccoons. J. Wildl. Mgmt. 29:898-902. (COO-1332-5)
- Mech, L. D. and J. R. Tester. 1965. Biological, behavioral, and physical factors affecting home ranges of snowshoe hares, raccoons, and white-tailed deer under natural conditions. Minn. Mus. Nat. Hist., Tech. Rept. 9, 11 pp. mimeo. (COO-1332-23)
- Mech, L. D., J. R. Tester and D. W. Warner. 1966. Fall daytime resting habits of raccoons as determined by telemetry. J. Mamm. In press. (COO-1332-13)
- Mech, L. D. and F. Turkowski. 1966. Twenty-three raccoons in one winter den. J. Mamm. In press. (COO-1332-14)
- Schneider, D. G., L. D. Mech and J. R. Tester. 1966. An eight-month radio-tracking study of raccoon families. Bull. Ecol. Soc. Amer. In press. (COO-1332-20)
- Schneider, D. G., L. D. Mech, and J. R. Tester. Changes in movement of a female raccoon after abandonment of young. Submitted to J. Mamm. (COO-1332-21)
- Siniff, D. B. 1966. Computer programs for analyzing radio-tracking data. Minn. Mus. Nat. Hist., Tech. Rept. 12. 10 pp. mimeo. (COO-1332-18)

- Siniff, D. B. and J. R. Tester. 1965. Computer analysis of animal-movement data obtained by telemetry. *BioSci.* 15(2):104-108. (C00-1332-3)
- Tester, J. R. In press. Status and value of biotelemetry in studies of vertebrate ecology. *Proc. Intl. Union Game Biol.* 7: . (C00-1332-12)
- Tester, J. R. 1966. Automatic radio-tracking system for studying animal movement and behavior. (motion picture) *Bull. Ecol. Soc. Amer.* In press. (C00-1332-19)
- Tester, John R. and John C. Moulton. 1965. Movements and activity of pen-raised white-tailed deer (Odocoileus virginianus) after release in unfamiliar habitat. (abstract) *Bull. Ecol. Soc. Amer.* 46(3):121. (C00-1332-8)
- Tester, J. R. and D. B. Siniff. 1965. Aspects of animal movement and home range data obtained by telemetry. *Trans. N. Amer. Wildl. Conf.* 30:379-392. (C00-1332-4)
- Turkowski, F. and L. D. Mech. An intensive analysis of the movements of a young male raccoon. Submitted to *J. Mamm.* (C00-1332-22)

THESES

- Heezen, Keith L. 1965. Evaluation of animal-location data obtained by triangulation with observations on winter and spring movements of white-tailed deer in Minnesota. *Univ. Minn., M.S. Thesis.*
- Moulton, John C. 1966. Movement and activity of three white-tailed deer during the winter of 1964-1965 in east-central Minnesota determined by telemetry. *Univ. Minn., M.S. Thesis.*

PAPERS PRESENTED

- August 26, 1964. Dr. Tester organized and chaired special AIBS Symposium, "Studies of Animal Activity by Means of Biotelemetry." Boulder, Colorado. Presented two papers: "Scope and Perspective" and "Automation in Animal Tracking."
- June 22, 1965. Annual Meeting of American Society of Mammalogists, Winnipeg, Manitoba. Four papers presented by project personnel:
- (1) Warner, D. W. and J. R. Tester. Automatic radio-tracking system for studying animal movements.
 - (2) Mech, L. D. and J. R. Tester. Fall denning activity of raccoons determined by telemetry.
 - (3) Mech, L. D. Late winter and spring movements of snowshoe hares as determined by telemetry.
 - (4) Schnell, J. H. An experimental investigation of carrying capacity in the cotton rat (Fieldwork conducted at Laboratory of Radiation Ecology, Aiken, S. Carolina).

August, 1965. Ecological Society of America, Meeting with AIBS, Urbana, Illinois.

- (1) McKinney, D. F. An analysis of pair-formation in Anas crecca carolinensis.
- (2) Mech, L. D. A critical evaluation of the concept of home range.
- (3) Tester, J. R. and J. C. Moulton. Movements and activity of pen-raised white-tailed deer after release in unfamiliar habitat.

September, 1965. 9th International Ethological Congress, Zurich, Switzerland.

- (1) McKinney, D. F. Pair formation in Anas crecca carolinensis.

March, 1966. North American Wildlife and Natural Resources Conference, Pittsburgh, Pa.

- (1) Siniff, D. B. Analysis of radio tracking data by digital computer.

August, 1966. Animal Behavior Society, Meeting with AIBS, College Park, Md. One paper to be presented:

- (1) Tester, J. R. Automatic radio-tracking system for studying animal movement and behavior (motion picture).

August, 1966. Ecological Society of America, Meeting with AIBS, College Park, Md. One paper to be presented:

- (1) Schneider, D. G., L. D. Mech and J. R. Tester. An eight-month radio-tracking study of raccoon families.

November, 1966. Conference on Engineering in Medicine and Biology. San Francisco, Calif. One paper to be presented:

- (1) Tester, J. R. Biotelemetry and Ecology.

LITERATURE CITED IN PROGRESS REPORT
AND/OR
RENEWAL PROPOSAL

- Allred, Donald M. and D. Elden Beck. 1963. Range of movement and dispersal of some rodents at the Nevada Atomic Test Site. J. Mammal. 44(2):190-200.
- Bennett, L. J. 1938. The Blue-winged Teal. Ames, Iowa: Collegiate Press.
- Blair, W. Frank. 1953. Population dynamics of rodents and other small mammals. Advances in Genetics 5:2-41.
- Brakhage, G. K. 1965. Biology and behavior of tub-nesting Canada Geese. J. Wildl. Mgmt. 29:751-771.
- Burt, William H. 1943. Territoriality and home range concepts as applied to mammals. J. Mammal. 24(3):346-352.
- Cochran, W.W., D. W. Warner, J. R. Tester and V. B. Kuechle. 1965. Automatic radio-tracking system for monitoring animal movements. Bio-Sci. 15(2):98-100.
- Cockrum, E. Lendell. 1962. Introduction to mammalogy. The Ronald Press Co., New York. 455 pp.
- Dane, B., C. Walcott and W. H. Drury. 1959. The form and duration of the display actions of the Goldeneye (Bucephala clangula). Behaviour 14:265-281.
- , and W. G. van der Kloot. 1964. An analysis of the display of the Goldeneye duck (Bucephala clangula). Behaviour 22:282-328.
- Davis, D. E. 1953. Analysis of home range from recapture data. J. Mammal. 34:352-358.
- Davis, D.E., and F. B. Golley. 1963. Principles in Mammalogy. Reinhold Pub. Corp., New York. 335 pp.
- Dzubin, A. 1955. Some evidences of home range in waterfowl. Trans. 20th N. Amer. Wildlife Conf., pp. 278-298.
- , 1957. Pairing display and spring and summer flights of the Mallard. Blue Jay 15:10-13.
- Gates, J. M., 1962. Breeding biology of the Gadwall in northern Utah. Wilson Bulletin 74:43-67.
- Gates, J. M. 1965. Duck nesting and production on Wisconsin farmlands. J. Wildl. Mgmt. 29:515-523.
- Geyr von Schweppenburg, H. F. 1953. Zum Reihem der Enten. Journal für Ornithologie. 94:117-127.
- Glover, F. A. 1956. Nesting and production of the Blue-winged Teal (Anas discors, Linnaeus) in northwest Iowa. J. Wildl. Mgmt. 20:28-46.

- Greig-Smith, P. 1957. Quantitative plant ecology. Academic Press, Inc. New York.
- Guhl, A. M. 1962. The behavior of chickens. In: The behavior of domestic animals. Ed. by E. S. E. Hafez. Bailliere, Tindall and Cox, London. 619 pp.
- Hammond, M. C. and W. R. Forward, 1956. Experiments on causes of duck nest predation. J. Wildl. Mgmt. 20:243-247.
- Hammond, M. C. and G. E. Mann. 1956. Waterfowl nesting islands. J. Wildl. Mgmt. 20:345-352.
- Hawley, V. D. and F. E. Newby. 1957. Marten home ranges and population fluctuations. J. Mammal. 38:174-184.
- Hayne, Don W. 1949. Calculation of size of home range. J. Mammal. 30(1):1-18.
- Heezen, K. L. and J. R. Tester. Evaluation of animal location data obtained by triangulation. J. Wildl. Mgmt. In press. (COO-1332-15)
- Heezen, K. L. and J. R. Tester. Observations on winter and spring movements of white-tailed deer in Minnesota obtained by radio-tracking. Submitted to J. Wildl. Mgmt. (COO-1332-17)
- Henshaw, P. S. 1963. Radiation effects and peaceful uses of atomic energy in the animal species. In: Radioecology. Ed. by V. Schultz and A. W. Klement, Jr., AIBS and Reinhold, New York. 746 pp.
- Hinde, R. A. 1956. The biological significance of the territories of birds. Ibis 98:340-369.
- Hochbaum, H. A. 1944. The Canvasback on a prairie marsh. American Wildlife Institute, Washington, D.C.
- Hunt, E. G. and William Anderson. 1966. Renesting of ducks at Mountain Meadows, Lassen County, California. Calif. Fish and Game. 52:17-27.
- Jenkins, D. W. 1944. Territory as a result of despotism and social organization in geese. Auk 61(1):30-47.
- Johnsgard, P. A. 1960. A quantitative study of sexual behavior of Mallards and Black Ducks. Wilson Bulletin 72(2):133-155.
- Kalmbach, E.R. 1937. Crow-waterfowl relationships in the Prairie Provinces. Trans. N. Amer. Conf. 2:380-392.
- Keith, L. B. 1961. A study of waterfowl ecology on small impoundments in southeastern Alberta. Wildl. Mono. 6. 88 pp.
- Lind, H. 1958. Eine Untersuchung über das Balzverhalten der Kolbenente (Netta rufina pallas). Zeitschrift für Tierpsychologie 19:607-625.
- Lind, H. 1959. Studies on courtship and copulatory behaviour in the Goldeneye (Bucephala clangula L.). Dansk Orn. Foren. Tidsskr. 53:177-219.

- , 1962. Zur Analyse des sexuellen Verhaltens der Kolbenente, Netta rufina (Pallas). Zeitschrift für Tierpsychologie 19:607-725.
- Lorenz, K. 1941. Vergleichende Bewegungsstudien an Anatinen. Journal für Ornithologie 89:194-294.
- Lorenz, K. 1953. Comparative studies on the behaviour of the Anatinae. Reprinted from Avicultural Magazine.
- Lorenz, K. 1958. The evolution of behaviour. Scientific American 199 (6):67-78.
- Masure, R. H. and W. C. Allee. 1934a. The social order in flocks of the common chicken and pigeon. Auk 51(4):306-325.
- Masure, R. H. and W. C. Allee. 1934b. Flock organization of the shell parakeet. Ecology 15(4):388-398.
- McKinney, F. 1961. An analysis of the displays of the European Eider Somateria mollissima mollissima (Linnaeus) and the Pacific Eider Somateria mollissima v. nigra Bonaparte. Behaviour Supplement VII.
- McKinney, F. 1965a. The displays of the American Green-winged Teal. Wilson Bull. 77(2):112-121.
- McKinney, F. 1965b. Chasing and spacing in breeding ducks. Wildfowl Trust, Annual Report 1965.
- Mech, L. David. 1965a. A critical evaluation of the concept of home range. (abstract) Bull. Ecol. Soc. Amer. 46(3):121. (C00-1332-9)
- Mech, L. David. 1965b. The wolves of Isle Royale. Nat. Parks Fauna Ser. No. 7, 210 pp.
- Mech, L. D., K. L. Heezen, and D. B. Siniff. 1966. Onset and cessation of activity in cottontail rabbits and snowshoe hares in relation to sunset and sunrise. Animal Behavior. In press. (C00-1332-15)
- Mech, L. D., V. B. Kuechle, D. W. Warner, and J. R. Tester. 1965. A collar for attaching radio transmitters to rabbits, hares, and raccoons. J. Wildl. Mgmt. 29(4):898-902. (C00-1332-5)
- Mech, L. D., J. R. Tester, and D. W. Warner. 1966. Fall daytime resting habits of raccoons as determined by telemetry. J. Mamm. In press. (C00-1332-13)
- Mendall, H.L. 1958. The Ring-necked Duck in the northeast. University of Maine Studies, Second Series, No. 73.
- Mitchell, James L. 1961. Mink movements and populations on a Montana river. J. Wildl. Mgmt. 25:48-54.
- Morisita, M. 1954. Estimation of population density by spacing method. Mem. Fac. Sci. Kyushu Univ., E (Biol.), 1:187-197.

- Moulton, John C. 1966. Movement and activity of three white-tailed deer during the winter of 1964-1965 in east-central Minnesota determined by telemetry. Univ. Minn., M.S. Thesis.
- Nice, M.M. 1941. The role of territory in bird life. Amer. Mid. Nat. 26:441-487.
- Schjelderup-Ebbe, T. 1922. Beitrage zur Sozialpsychologie des Haushuhns. Zeit. fur psychol. 88:225-252.
- Schneider, D. G., L. D. Mech, and J. R. Tester. Changes in movement of a female raccoon after abandonment of young. Submitted to J. Mamm. (C00-1332-21)
- Sibley, C. G. 1957. The evolutionary and taxonomic significance of sexual dimorphism and hybridization in birds. Condor 59:166-191.
- Siniff, D. B. 1966. Computer programs for analyzing radio-tracking data. Minn. Mus. Nat. Hist., Tech. Rept. 12. 10 pp. mimeo.(C00-1332-18)
- Siniff, D. B. and J. R. Tester. 1965. Computer analysis of animal-movement data obtained by telemetry. BioSci. 15(2):104-108.
- Smith, R. I. 1963. The social aspects of reproductive behavior in the Pintail, Anas acuta acuta L. Ph.D. Thesis, Utah State University, Logan, Utah.
- Sowls, L. K. 1955. Prairie ducks. Stackpole Co. Harrisburg, Pa. 193 pp.
- Stockel, L. F. 1954. A comparison of certain methods of measuring ranges of small mammals. J. Mammal. 35:1-15.
- , 1960. Peromyscus ranges at high and low population densities. J. Mammal. 41:433-440.
- , and O. Warbach. 1960. Small-mammal populations of a Maryland woodlot, 1949-1954. Ecology 41:269-286.
- Tester, J. R. 1963. Radio tracking of ducks, deer, and toads. Univ. Minn. Mus. Nat. Hist. Tech. Report No. 6. Mimeo.
- Tester, J. R., and K. L. Heezen. 1965. Deer response to a drive census determined by radio-tracking. BioSci. 15(2):100-104.
- Tester, John R. and John C. Moulton. 1965. Movements and activity of pen-raised white-tailed deer (Odocoileus virginianus) after release in unfamiliar habitat. (abstract) Bull. Ecol. Soc. Amer. 46(3):121 (C00-1332-8)
- Tester, J. R. and D. B. Siniff. 1965. Aspects of animal movement and home range data obtained by telemetry. Trans. N. Amer. Wildl. Conf. 30:379-392. (C00-1332-4)
- Tester, J. R., D. W. Warner and W.W. Cochran. 1964. A radio-tracking system for studying movements of deer. J. Wildl. Mgmt. 28(1):42-45.

- Thompson, W. L. 1960. Agonistic behavior in the house finch. Part II: Factors in aggressiveness and sociality. *Condor* 62(5):378-402.
- Tinbergen, N., G. J. Broekhuysen, F. Feekes, J. C. W. Houghton, H. Kruuk, and E. Szulc. 1962. Egg shell removal by the Black-headed Gull, Larus ridibundus L.; a behaviour component of camouflage. *Behaviour* 19:74-117.
- Turkowski, F. and L. D. Mech. An intensive analysis of the movements of a young male raccoon. Submitted to *J. Mamm.* (C00-1332-22)
- Weidmann, U. 1956. Verhaltensstudien an der Stockente (Anas platyrhynchos L.) I. Das Aktionsystem. *Zeitschrift für Tierpsychologie*. 13:208-271.

APPENDIX A

Mortality of three species of ducks, Anas discors, A. crecca and A. clypeata, exposed to ionizing radiation.

This paper reports on differences in radiation sensitivity among Blue-winged Teal (Anas discors), Green-winged Teal (A. crecca) and Shovelers (A. clypeata) exposed to whole-body gamma irradiation from cesium-137. The experiments were conducted to provide baseline information requisite to our studies of the effects of ionizing radiation on breeding behavior in selected species of ducks.

It was anticipated that the radiation response of the three species of ducks would be similar because all belong to the same genus and are considered closely related. In addition, we believed that the LD₅₀₋₃₀ would be in excess of 800-900r on the basis of lethal dose studies of various species of birds as reviewed by Tester and McKinney (1963). Our experiments suggested, however, that the three species varied greatly in degree of radiation resistance and that both species of Teal were more radiation sensitive than other species of birds which have been studied.

METHODS

Most ducks were obtained directly from the wild as either flightless young or adults. Adult Blue-winged Teal were bait-trapped at the Agassiz National Wildlife Refuge in northwestern Minnesota. Adult Green-winged Teal were bait-trapped in central California and shipped by air to Minneapolis. The teal of both species were held in outdoor flight pens for approximately one month to allow them to become acclimated to captivity. Some of the Shovelers had been raised from "wild" eggs at the Delta Waterfowl Research Station in Manitoba, but most were drive-trapped as flightless young in the Dakotas. All but one of the Shovelers had been in captivity for more than one year (most for several years); one individual was captured as a molting adult in North Dakota three months before irradiation. The Shovelers and Blue-winged Teal were full-winged, but the Green-winged Teal were feather-clipped.

The irradiations consisted of single dose, total-body exposures to a 10,000 curie cesium-137 source delivered in the University of Minnesota Gamma Irradiation Facility. The dose rate in all experiments was 51r per minute as determined with both a Victoreen Rated Meter and ferrous sulphate (Fricke) dosimetry. Source configuration was 10 cesium-137 pencils in a 5 inch diameter holder. Boxes, each holding one duck, were centered on the arc of a circle with a 34.5 inch radius from the source center and were oriented so that irradiation was received laterally. Figures 1 and 2 show the arrangement of the boxes. The source, under water in the illustration, is raised by remote control to a position directly under the circular plate located within the three vertical rods.

Birds were transported to and from the irradiation site, a distance of 35 miles, in screened cages and were placed in the cardboard boxes immediately prior to irradiation (Figure 2). Total doses for the experimental groups ranged from 400 to 1600 r. The length of time that the source was in the "up" position was varied to give the appropriate dose for each test group. Control groups were handled in the same manner as exposed groups except that the boxes containing the birds were not placed inside the

Figure 1. Configuration of boxes holding the ducks during irradiation, showing a Blue-winged Teal being placed in position.

Figure 2. Placement of boxes holding ducks inside the Gamma Irradiation Facility. The source, under water in the illustration, is raised by remote control to a position directly under the circular plate located within the three vertical rods in the center, rear of the photo.

irradiation chamber. The birds were returned to their flight pens one to four hours following irradiation.

Two separate tests were carried out on fully winged adult female Blue-winged Teal. On October 15, 1964 five groups of 10 birds each were exposed to 800, 1000, 1200, 1400 and 1600 r, and one control group of 10 was "sham" irradiated. These birds were all housed in a 90 x 90 ft. outdoor flight pen both before and after exposure. These doses were found to be too high and all dose levels except the 800 r group had 100% mortality, thus these data were not satisfactory for LD₅₀₋₃₀ determination and are excluded in these computations. On October 15, 1965 groups of 10 birds were exposed to 600, 700, 800, 900 and 1000 r, with one control group being "sham" irradiated. These birds were housed in the same flight pen as the 1964 group.

Five groups of eight fully-winged Shovelers received 500, 700, 900, 1100 r and "sham" irradiation on October 20, 1965. These groups were composed of both adult males and adult females because we could not obtain enough Shovelers to use only one sex. They were housed in the same large flight pen as the experimental Blue-winged Teal.

The Green-winged Teal test was conducted in the spring of 1966 on adult male birds which had been wing-clipped at time of capture to prevent flight. Groups of nine received 400, 600, 800, 1000 r and "sham" irradiation on May 18, 1966. Prior to irradiation, these birds were held for one month in relatively small flight pens (400 r and 600 r groups in triangular pens 30 x 30 x 30 ft; the other groups in rectangular 16 x 20 ft pens). Following irradiation they were returned to pens of similar size.

The ducks were checked daily during the first month after irradiation to remove dead birds and to make behavioral observations. Dead ducks were either autopsied within a few hours after death or were frozen for future autopsy. At the end of the 30 day period for some experiments, the surviving birds were captured and brought alive to the University of Minnesota Veterinary Diagnostic Laboratories for autopsy.

RESULTS

The lethal dose levels as determined by probit analysis for the three species are shown in Figure 3. The LD₅₀₋₃₀ obtained for Green-winged Teal is 485 r; for Blue-winged Teal is 715 r, and for Shovelers is 894 r. Only one bird died in any of the control groups; this was a Blue-winged Teal which was found dead on the 15th day after treatment, for the 1964 experiment.

Most deaths at the higher doses in both species of Teal occurred during the first 24 hours following irradiation. Birds which died during this period were found both on shore and in the ponds of the flight pens. No deaths occurred in the 30-day test period for Blue-winged Teal after day 15 in 1964 or after day 21 in 1965; after day 19 in the Shoveler test; or after day 27 in the Green-winged Teal.

All birds which died after the first 24 hours post-irradiation were found on shore. Many of these were in a "natural" resting position with the head upright and appearing to rest on the breast. These birds obviously did not struggle or become violent while dying.

Figure 3. Computed 30%, 50%, 70%, and 90% lethal doses for a 30 day period after irradiation for three species of ducks as determined by probit analysis.

Daily observations revealed that birds which appeared listless or were unable to fly were usually in a stage 24 to 48 hours prior to death. A detailed study of effects of radiation on behavior is in progress and results will be reported separately.

Necropsy findings will be discussed briefly below; a more complete evaluation will be made when results have been obtained from the recent experiments and from some of the frozen specimens.

Gross autopsy findings of those birds that died during the first 24 hours post-irradiation revealed that death was due to profuse, generalized intestinal hemorrhages. The small intestines of these birds were usually filled with clotted blood and hemorrhages were sometimes present in other parts of the gastro-intestinal tract such as the proventricular junction and the pylorus. These findings appear to support those of Stearner and her co-workers who reported that in chickens and possibly other species of birds the radiation response differs from that in mammals. Mammalian deaths in general are characterized by hematopoietic failure and at higher doses, intestinal damage. In chickens a third mortality factor, characterized by circulatory collapse and renal failure, seems to operate within the first two days after exposure (Stearner, et al., 1960 and Stearner and Tyler, 1957a).

Those birds examined which died from four to 67 days post-irradiation appeared to have died from hematopoietic failure as evidenced by the pale pink to white color of the bone marrow and by low hemoglobin values and high erythrocyte fragility. Most ducks which died during the first 24 hours had normal bone marrow.

Staphylococci were isolated from liver cultures from three Blue-winged Teal which died 7, 9, 9 and 67 days after receiving 1600, 1600 and 800 r, respectively and from one Blue-winged Teal in the control group which died 32 days after "sham" irradiation. The two "9-day" birds showed no visible signs of Staphylococci and probably died from hemorrhages; whereas, the "67-day" and control birds had heavy bacterial infections as shown by swollen, green-colored livers which might have caused death.

DISCUSSION

The observed differences in radiation resistance of these three species may represent real specific variability, but they may have been caused by a number of other factors. The experiments are not strictly comparable since there were differences in the sex and age of the groups used, experiments were not all carried out at the same time of year, the birds in one group were wing-clipped while the others were full-winged, and the same size of pen was not used in all cases.

Our results suggest that the Shoveler is the most radiation-resistant species (LD₅₀₋₃₀: 894 r), but the birds used in our experiments were adults which were well adapted to captivity and human disturbance. The Blue-winged Teal we used had been in captivity for a shorter period and it is possible that the lower lethal dose (715 r) reflects the greater stress of captive conditions. The Green-winged Teal test was carried out in spring (the other species were tested in fall), the birds were kept in smaller pens and were feather-clipped, so it is very likely that these birds were under additional stress, perhaps sufficient to account for the LD₅₀₋₃₀ of 485r.

In addition to these variables related to experimental conditions, it is possible that specific body-size differences are involved in radiation resistance. The Shoveler is the largest species, the Green-winged Teal the smallest. Also, there are specific differences in the adaptability of these species to captivity; the Shoveler and Blue-winged Teal settle down quickly and become tame, but Green-winged Teal always remain nervous and extremely timid in captivity.

We are not able to evaluate the potential effects of these variables with the available data. It is hoped that future experiments can be conducted to provide relevant information on these factors.

LITERATURE CITED

Stearner, S. P., M. H. Sanderson, E. J. Christian and S. A. Tyler. 1960. Factors influencing the initial lethal response of the irradiated chick. *Rad. Res.* 12(4): 475-476.

_____ and S. A. Tyler. 1957. Recognition of modes of death in the analysis of acute radiation mortality. In: *Biological and Medical Research Div., Semiannual Rept., Argonne Natl. Lab., USAEC Rept. ANL-5732.* pp. 98-101.

Tester, J. R. and D. F. McKinney. 1963. Review of literature pertaining to a study titled effects of ionizing radiation on certain aspects of the breeding behavior of selected species of Anatidae. Univ. Minn., Mus. Nat. Hist., 25 pp. mimeo.