Effect of Low-level Flying Military Aircraft on the Behaviour of Spring Staging Waterfowl at Lac Fourmont *ashkui*, Labrador, Canada

by

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PREFACE

This is a manuscript-based thesis which consists of three chapters and is in accordance with the Guidelines for Thesis Preparation of the Faculty of Graduate and Postdoctoral Studies and Research of McGill University. The literature review of Chapter 1 provides biological background information on each of the three study species: Common Goldeneye, Black Duck and Canada Geese. The biological importance of migration and spring-staging to these species is addressed. This chapter also introduces the reader to the subject of noise as a disturbance to waterfowl and defines the Innu term *ashkui.* While collecting data on the effects of low-level flying of military aircraft on the behaviour of spring staging waterfowl, time-activity budgets for three waterfowl species were compiled. Details are presented in Chapter 2: **Time-activity budgets of spring-staging waterfowl at Lac Fourmont *ashkui*, Labrador, Canada**. Weather, time of day, pair status and sex are included in the analyses of time-activity budget data. Changes in time activity budgets are related to the passage of military aircraft and how long these changes in behaviour occur after over-flights is presented in Chapter 3: **Effect of Low-level flying military aircraft on the behaviour of spring-staging waterfowl at Lac Fourmont *ashkui*, Labrador, Canada**. This final chapter also aims to highlight recommendations for future study to better address concerns that may exist with regard to low-level jet over-flights and effects on waterfowl.

Animal care certification was not necessary for this observational study, which was conducted at a distance in a natural setting.

The candidate believes that the information presented in this manner forms a cohesive unit with a logical progression and is in accordance with the Guidelines for Thesis Preparation by the Graduate and Postdoctoral Studies Office of McGill University.

ABSTRACT

Military jet over-flight activities pose a potential threat to staging waterfowl and pilots. The migration period is important for nutrient acquisition and courtship as these waterfowl enter the breeding season. Using a focal animal (continuous) technique for five-minute intervals, diurnal Time / Activity (TA) budgets for Canada Geese (*Branta canadensis canadensis*) (n=751), American Black Duck (*Anas rubripes*) (n=474) and Common Goldeneye (*Bucephala clangula*) (n=1274) were compiled during 216 hours of behavioural observation. The study was conducted from 26 April to 27 May, 2002 at the outlet of Lac Fourmont, Labrador (52° 03' 30"N, 60° 31' 01" W), in an *ashkui* or area of open water in an otherwise frozen landscape, which is known historically as a place to hunt waterfowl. These staging grounds are within the 130 000 km^2 Low-level Training Area (LLTA) of the Quebec-Labrador Peninsula. Generalized Linear Modeling (GLM) of ranked variables was used to analyze behaviour by: observer, sex, pair status, time of day, date, and each weather parameter. Male Common Goldeneye spent more time in courtship behaviours (2.7%) than females (1.1%) and they spent most of the daylight hours feeding (males 53.3% and females 54.5%), with little time resting (4.8% and 5.2%, respectively). In contrast, Black Ducks and Canada Geese spent relatively little time feeding (12.4% and 5% respectively) and most of their time sleeping (35% and 38% respectively) and locomotion (37.8% and 11% respectively). *Ashkui* are important to Common Goldeneyes for foraging, and to Canada Geese and Black Ducks for resting prior to the breeding season.

Ninety-one low-level jet over-flights occurred and sound levels (n=336 h) at the study site were measured. Effects of low-level jet over-flights were analyzed using GLM of ranked variables in order to analyze a number of variables simultaneously. All behavioural observations that occurred in the quarter hour periods up to 165 minutes after an over-flight were analyzed. Alert and courtship behaviours of Canada Geese increased after over-flights. Other behaviours were negatively affected to a lesser degree. Locomotor activities by Black Ducks increased significantly immediately following over-flights with a stronger movement response with increased noise. Increases in agonistic and comfort behaviours of Common Goldeneye were detected following over-flights with few other significant affects on their behaviour.

Key words: *Anas rubripes, Branta canadensis, Bucephala clangula,* disturbance, jet aircraft, Labrador, low-level flying, military activity, noise, spring staging, time-activity budgets, waterfowl

RÉSUMÉ

Les survol de haltes migratoires d'oiseaux aquatiques par les aéronefs militaires créé un danger pour les oiseaux et les pilotes. La période de migration est un moment important pour l'acquisition de nutriments et pour la parade nuptiale puisque la saison de reproduction de ces oiseaux s'amorce. À l'aide de la technique d'observation continue d'un oiseau focal par intervalle de 5 minutes, des bilans d'activitiés diurnes pour la Bernache du Canada (*Branta canadensis canadensis*) (n=751), le Canard Noir (*Anas rubripes*) (n=474) et le Garrot à l'œil d'or (*Bucephala clangula*) (n=1274) furent enregistres. Il y eut 216 heures d'observation comportementale et les données météorologiques furent enregistrées pour tout période d'observation. L'étude fut menée du 26 avril au 27 mai 2002 à la bouche du Lac Fourmont au Labrador (52° 03' 30"N, 60° 31' 01" W), une nappe d'eau dépourvue de glace au printemps. Cet endroit est connu historiquement comme lieu de chasse à la sauvagine (*ashkui*). Ces haltes migratoires se trouvent à l'intérieur du terrain d'entraînement à basse altitude de 130 000 km^2 du Péninsule Québec-Labrador. La modélisation linéaire généralisée (MLG) de variables ordonnées fut utilisée pour analyser le comportement selon l'observateur, le sexe, l'accouplement, l'heure, la date et les paramètres métèrologiques. Le Garrot à œil d'or mâle passe plus de temps à la parade nuptiale (2,7 %) que la femelle (1,1 %) et ils consacrent la majorité des heures de clarité à s'alimenter (mâles 53,3 % et femelles 54,5 %) et peu de temps à se reposer (4,8 % et 5,2 %). Par contre, les Canards Noirs consacrent peu de temps à s'alimenter (12,4 %) et la majorité de leur temps à dormir (35 %)

et à se déplacer (37,8%), mais moins de 1% est accordé aux comportements de la parade nuptiale. Les *ashkui* sont importants pour l'alimentation des Garrots à œil d'or et pour le repos des Bernache du Canada et des Canard Noirs avant la saison de reproduction.

Quatre-vingt-onze vols à basse altitude furent enregistrés et les relevés de bruit furent mesurés (n=336 h). La MGL a permis l'analyses des variables ordonnées afin d'en étudier un grand nombre simultanément. Toute observation comportementale dans les 165 minutes après le passage d'un aéronef fut comptabilisée par période de 15 minutes. Des effets furent observés sur le comportement de vigilance et de la parade nuptiale des Bernaches du Canada. D'autres comportements furent affectés de façon néfaste moins prononcée. Les activités de déplacement des Canards Noirs ont augmentées de façon significative à la suite immédiate d'un survol : plus le bruit était fort, plus le mouvement de réaction était prononcé. Le Garrot à œil d'or a démontré des comportements agonistiques et de confort plus prononcés.

Mots clés : *Anas rubripes, Branta canadensis, Bucephala clangula,* perturbation, avions à reaction, Labrador, vols à basse altitude, activités militaires, bruit, halte migratoire printanière, bilan d'activités, oiseaux aquatiques.

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Contributions of Authors

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CHAPTER 1: Introduction and Literature Review

INTRODUCTION

Understanding why and where waterfowl migrate and stage in spring are keys to assessing effects of disturbance at this brief time in their annual cycle. To measure the potential effect of noise we need to determine how birds allocate their time to various behaviours (*i.e.* time-activity budgets). Several authors (Titman 1981; Bélanger and Bédard 1989, 1990; Conomy *et al.* 1998; Ward *et al.* 1999) have provided details of time-activity budgets for waterfowl but very little research has been carried out on the selected research species in the boreal forest or at this critical time of year.

Spring staging sites are essential areas of migration stopover, a necessary component of waterfowl habitat, before birds reach the breeding grounds. Birds may return to the same staging areas year after year (Palmer 1976). The ability of migratory birds to store and utilize large amounts of fat has been known for some time (Odum 1960). This ensures that they are capable of long flights and that their arrival at the breeding grounds is coincident with weather conditions suitable for breeding (Odum 1960). Migratory waterfowl begin to accumulate fat reserves before the onset of migration but significant fat deposition can occur at a spring-staging site (Krapu 1981). Some waterfowl have adapted to migrate before acquiring maximum fat deposits. Staging prior to reaching the breeding grounds is necessary to rebuild nutrient reserves before the final leg of the trip. Birds may acquire large amounts of lipids and build fat stores for the final leg of migration and breeding (Raveling 1979).

Canada Geese (*Branta canadensis*) acquire most of their nutrients for reproduction while on wintering and/or staging areas prior to their arrival on the breeding grounds. Geese appear to time their arrival at the spring staging areas to coincide with the availability of forage (McLandress and Raveling 1981; Ebbinge and Spaans 1995). A failure to breed can be caused by unsuitable foraging on the staging and/or breeding grounds (Krapu and Reinecke 1992). These birds need to be at their peak body condition upon arrival on the breeding grounds to meet the energetic demands of reproduction. Reserves provide energy for migration and reproduction and there is considerable evidence that food resources available to pre-breeding and breeding waterfowl influence reproductive performance in several ways: 1) timing of reproduction, 2) failure to breed, 3) clutch size, 4) egg mass and composition, 5) egg fertility and hatchability, and 6) occurrence and frequency of re-nesting (McLandress and Raveling 1981, Krapu and Reinecke 1992). In general, geese use traditional spring-staging grounds. The theory that knowledge of food and predator distribution is an important determinant of site fidelity is one argument for repeated use of spring-staging grounds (Black *et al.* 1991, Reed *et al.* 1998).

***Ashkui* as Spring-Staging Areas**

Ashkui is an Innu term describing an area of open water on a lake or river that either never freezes or opens up first in the spring due to the influence of rivers and streams entering or exiting lakes. These openings are recognized as being highly biologically productive (i.e. a variety of wildlife use these areas) by both Innu and western scientists (Fletcher and Breeze 2000).

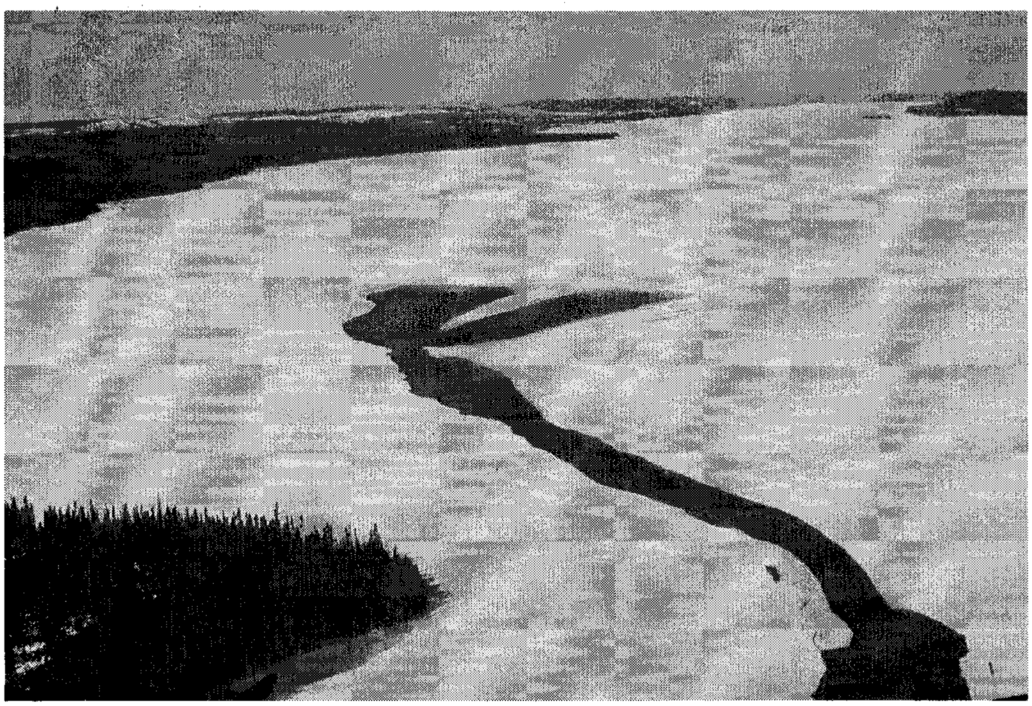

Figure 1.1: Lac Fourmont *ashkui,* Labrador, Canada in April 2002

Ashkui are commonly used locations by migrating waterfowl for resting and feeding because they are the only areas of open water during spring. As *ashkui* often occur in the same places annually, their locations are well known to Innu and are historically an important cultural resource.

Noise and Disturbance

Noise can be defined simply as unwanted sound. The noises generated by military aircraft are unique, in that different types of aircraft have different noise signatures, and therefore comparisons of effect of noise cannot be made with other aircraft or activity (Larkin *et al.* 1996). Aircraft noise is a stressor of wildlife and can alter the normal behaviour of animals (Delaney *et al.* 1999; Ward *et al.* 1999; Kull and Fisher 1986). Aircraft noise exceeds 120 on the logarithmic decibel (dB) scale. To put this in perspective, human speech occurs in the range of 20-60 dB and noise at 90dB can be damaging to the human ear (Bowles 1995). Wildlife response to noise can depend on a variety and combination of factors: noise level, duration of the noise event, number of noise events, frequency, and the existence and level of background noise.

Aircraft noise may be disguised or reduced by sounds in the natural environment (e.g. wind). For example, wind may prevent wildlife from hearing the approach of an aircraft resulting in a sudden, perhaps startling sound (Harrington and Veitch 1992).

Characteristics of the natural environment play a factor in sound propagation. To test the impact of noise on wildlife, noise measurements should be taken at the same location and at the same height above ground (Larkin *et al.* 1996).

Military Aircraft as Disturbance of Wildlife

Noise level is a major concern with low-level over-flights. Other factors that may result in disturbance from aircraft are visual stimuli, odours, vibrations, and the duration of exposure to the above. Waterfowl may interpret aircraft as predators. A visual observation of a military jet aircraft typically precedes the sound it produces (Harrington and Veitch 1992). Noise events may vary in level of disturbance as influenced by wind and other weather events (Raveling *et al.* 1972).

Responses to noise are species-specific (Larkin *et al.* 1996) and are influenced by a number of factors including aircraft type, duration of sound event, altitude, distance from animals, and size of animal group. In addition, the frequency of over-flights may influence the responses of animals to aircraft disturbance.

There may be both short and long-term effects to noise and disturbance. Several response categories can be used to evaluate sensitivity. Noise generated by low-level military jet aircraft typically is characterized as a gradual-onset sound but this may be altered by wind and become a rapid-onset sound.

Physiological responses include increased heart rate, effects on hearing, stress, audiogenic seizure, and effects on other body functions such as an increased metabolic activity in areas of the brain as a result of long-term habituation to noise. A startle response may occur when an animal is exposed to a sudden and loud noise (Larkin *et al.* 1996).

Behavioural responses may be both immediate and long-term. These responses include changes in feeding rate, increased levels of aggression, changes in home range, escape response or fleeing (leading to increased energy expenditure and accidents), avoidance (leading to reduced use or abandonment of habitat), and effects on reproductive activities (Larkin *et al.* 1996). Masking of communication may interrupt detection of prey or predators

(Anonymous 1994). Repeated noises may lead to decreased responsiveness, which can be attributed to habituation (Larkin *et al.* 1996). In addition, noise may mask environmental information relevant to animals, resulting in inappropriate responses. Noise has the potential to cause energy loss through evasive movement. Escape behaviours require energy expenditure (Ward *et al.* 1999). The exclusion of wildlife from suitable habitat due to a human-induced disturbance is often equivalent to mortality caused by man (Larkin *et al.* 1996). A response such as fleeing causes an increase in metabolic rate and thus an increase in energy expenditure (Geist 1971a,b). In this way a detectable change in behaviour can be used to quantify disturbance. Perhaps because waterfowl are hunted and because as migrants they may be unfamiliar with a particular disturbance, waterfowl may be more overtly responsive to noise than other birds (Thiessen *et al.* 1957).

Habituation is learned and is a permanent or temporary waning of the responsiveness of animals to repetitious events (Marler and Hamilton 1966). Habituation to disturbances that are not followed by disagreeable experiences (negative reinforcement) is a learned response (Geist 1971b). This is an adaptive response that reduces the time and energy wasted reacting to inconsequential stimuli in the environment (Alcock 1989). The ability to habituate depends on the regularity and frequency of the disturbance and differs among species. Habituation may also occur to a inconsequential noise.

Tolerance to noise can result from the need to secure food (Bowles 1995). An animal may forego a preferred habitat temporarily or for the long-term due to disturbance (Dufour 1980). Displacement may be particularly disruptive to animals such as waterfowl that are perennially dependent on the same locality for staging and breeding and may be cumulative.

Because a natural environment does have noise it cannot be assumed that human-generated noise will have a detrimental affect on wildlife species (Larkin *et al.* 1996). Similarly, a short-term response by an individual should not be misinterpreted as stressful. Studies should include measurable impacts on reproduction, habitat use, general health, and longevity (Harrington and Veitch 1992; Plumpton and Lutz 1993; Bowles 1995; Delaney *et al.*1999).

Geese may alter their activities in response to disturbance, even costly reductions in time spent foraging. Disruption to feeding activity may be detrimental to the energy balance of these animals (Bélanger and Bédard 1990; Tyler 1991).

The Effects of Noise Disturbance on Waterfowl

Geese may be more sensitive to noise during staging than during other periods of the year (Gollop *et al.* 1974; Salter and Davis 1974; Barry and Spencer 1976; Bélanger and Bédard 1989). While seeking refuge on open water to escape predation, Canada Geese are at risk to noise disturbances created by low-level military jet over-flights. This noise can influence the way staging geese use the habitat such as forcing them to flee or by altering time-activity budgets. Bélanger and Bédard (1989) found that Greater Snow Geese (*Anser caerulescens)* staging along the St. Lawrence during spring were disturbed most often by transport activities (including aircraft over-flights). As a result, geese spent more time in flight versus a hunting disturbance. Owens (1977) found that low-flying aircraft (<500 m altitude and up to 1.5 km distant) were particularly disturbing to Brant Geese (*Branta bernicla*), which were slow to habituate to aircraft and almost always took flight. Being over-flown by military aircraft during spring-staging may result in separation of members of a pair (Mackenzie 1976). However, there have not been any studies to examine the effects of military aircraft disturbance or other noise on waterfowl pair bonds (Anonymous 1994).

A sudden noise from low-level flying military aircraft is likely to elicit a startle response, which may elevate heart rate and alter the activities of waterfowl. A startle response may cause birds to take flight. An elevation in the metabolic rate that typically accompanies a rise in heart rate increases energetic expenditures (Wooley and Owen 1978).

American Black Duck (*Anas rubripes*) and Common Goldeneye (*Bucephala clangula*) are susceptible to noise (Eadie *at al.* 1995; Longcore *et al.* 2000). Noise generated by over-flight activity is an environmental stress that may interrupt pair formation during migration in these species. Black Ducks which are seasonally monogamous are wary birds that are susceptible to human disturbance, possibly more so than other duck species.

The migratory, seasonally monogamous Common Goldeneye habitat encompasses coastal areas from Newfoundland to Florida during fall and winter. Pair formation (also seasonally monogamous) begins during December and

January and continues through to spring (Afton and Sayler 1982). The *ashkui* used during spring-staging, appear to be important primarily as feeding areas (Eadie *et al.* 1995). This medium-sized, cavity nester breeds in forested areas of Labrador is a cavity nester. Degradation of habitat is a factor that affects Common Goldeneye populations and there are recorded incidents of population decline related to forest disturbance (Phillips 1925 *In* Eadie *et al.* 1995).

STUDY AREA

Low-level military training flights began on the Québec-Labrador Peninsula in 1981, over an undeveloped 130 000 km^2 area (Low-level Training Area; LLTA; Figure 1.1) and supports a diversity of wildlife in an undeveloped environment.

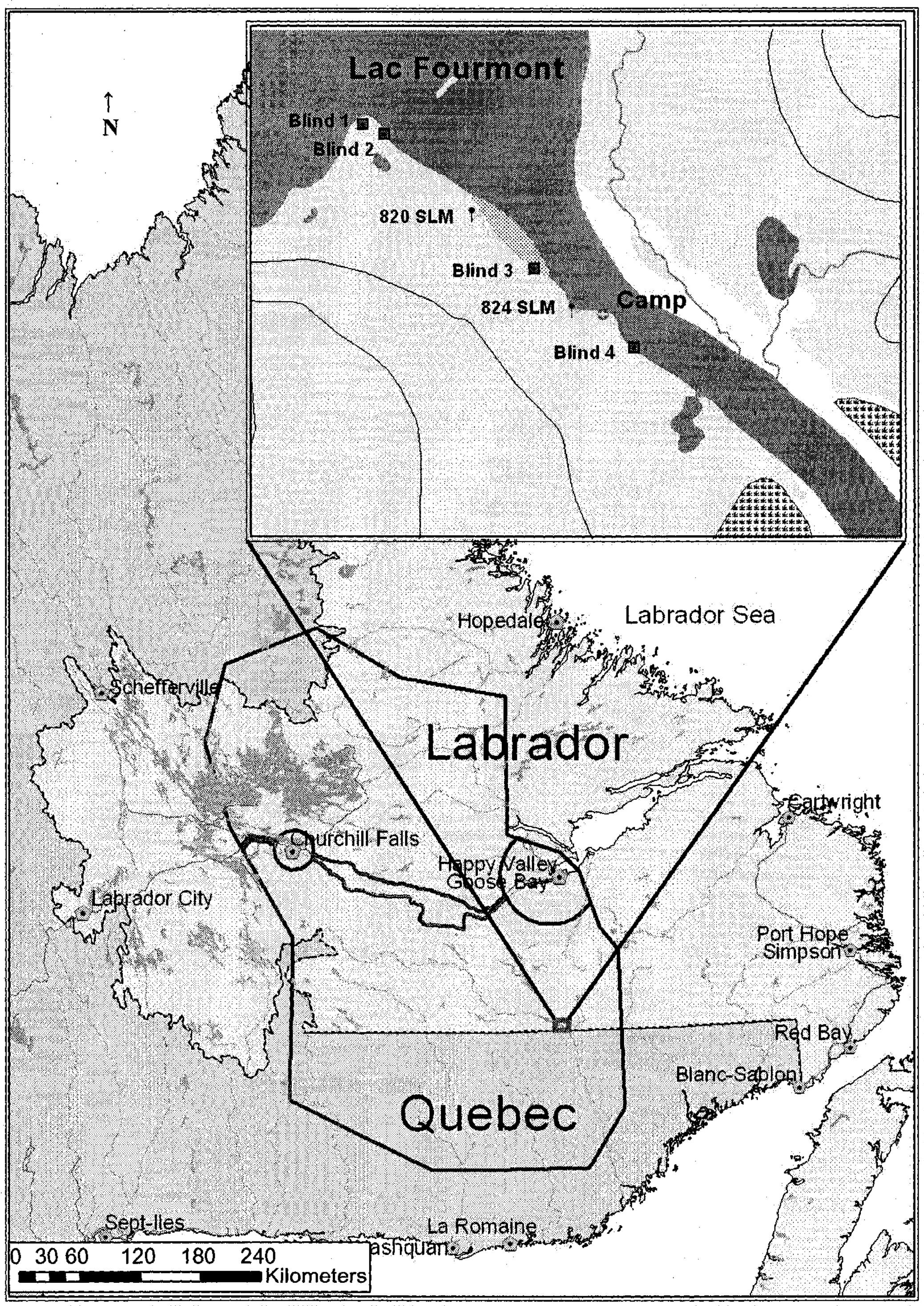

Figure 1.2: Location of study site at Lac Fourmont, Labrador, Canada. Black polygon indicates 130 000 km^2 Low Level Training Area. Inset shows location of camp, observation blinds and Sound Level Meters as well as detail of surrounding topography.

Flight training occurs here from April to October and waterfowl must contend with these military activities. The staging grounds overlap spatially and temporally with low-level flight training that occurs in the same area. One such staging ground is the Lac Fourmont *ashkui* (Figure 1.2). Concern from Innu and other residents about these flights increased during the early 1980's and in to the 1990's. There has been little research conducted on the short-term or long-term effects of military activity on spring-staging waterfowl within the boreal forest and in the LLTA of the Québec-Labrador Peninsula. In 1995, the Institute for Environmental Monitoring and Research (IEMR) was established to facilitate research on the effects of low-level over-flights on wildlife.

The Department of National Defense (DND) is concerned that spring-staging waterfowl may pose a threat to pilots and damage to aircraft. In addition, DND wishes to address the concerns of Innu and others. The Canadian Wildlife Service (CWS) is responsible for managing migratory waterfowl for they are a shared resource among hunters and naturalists across North America. The portion of the LLTA in Labrador and Québec that is used for flight training changes shape on the landscape daily to meet area closure requests from traditional land users, mitigation biologists, construction and fire control personnel. Effective flight closures minimize the amount of flight training space removed from the low-level training areas while still providing protection to sensitive wildlife.

Waterfowl comprise a substantial proportion of the avian species that migrate to Labrador to breed. Ducks and geese migrate to Labrador to time their arrival with favourable conditions for breeding during the spring. Waterfowl and other wildlife that visit the Lac Fourmont *ashkui* are highly valued primarily as a food source by residents. Three of the more common species are Canada Goose, American Black Duck and Common Goldeneye. Innu expressed concern to biologists of the Canadian Wildlife Service (CWS) and the Institute of Environmental Monitoring and Research (IEMR) about the effect low-level over-flights were having on spring-staging waterfowl. Their concerns related to altered behaviour, habitat avoidance, and taste of the meat (Tom Jung pers. comm.).

OBJECTIVES

The two objectives of this study are: (1) to describe the time-activity budget of Canada Goose, American Black Duck and Common Goldeneye staging during spring migration in Lac Fourmont *ashkui* in Labrador (2) to assess the behaviour of these three species in response to low-level flights military jets.

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CHAPTER 2: **Time-activity budgets of spring staging waterfowl at Lac Fourmont *ashkui*, Labrador, Canada**

INTRODUCTION

Time-Activity (TA) budgets measure the percentage of time that is spent daily by an animal in various activities. TA budgets of spring-staging waterfowl particularly for the eastern boreal forest are poorly known, despite this being an important time for nutrient acquisition and courtship for some species (Raveling 1979; Krapu 1981). More specifically, there is a lack of behavioural information for species that spring-stage during spring migration in the boreal forest. TA budgets can be used to describe the responses of waterfowl to environmental and habitat conditions (Quinlan and Baldasarre 1984).

Adult trumpeter swans (*Cygnus buccinator*) staging in Alberta spent (48% and 26%, respectively) of their time in feeding and resting. The TA budget of cygnets was similar. This suggests that spring-staging areas are important stopovers for building energy reserves for successful migration and breeding (LaMontagne *et al.* 2001).

Canada Goose (*Branta canadensis*), American Black Duck (*Anas rubripes*) and Common Goldeneye (*Bucephala clangula*) stage, breed and moult in parts of Labrador. These three waterfowl species have different requirements on the spring-staging grounds.

STUDY AREA

This research was conducted at the outlet of Lac Fourmont, Labrador (52° 03' 30" N, 60° 31' 01" W; Figure 2.1), a freshwater lake, approximately 180 km south of Goose Bay, Labrador and well within the confines of the 130 000 km^2

Low-level Training Area (LLTA) of the Quebec-Labrador Peninsula used by the military. Each year there are approximately 6,000 jet aircraft sorties in this LLTA. The study area lies within the Low Subarctic Forest – Mecatina River Ecoregion (Meades 1990). Lac Fourmont forms a part of the Little Mecatina watershed. This largely forested area is comprised primarily of black spruce (*Picea mariana*) and balsam fir (*Abies balsamea*). Interspersed are small numbers of balsam poplar (*Populus balsamifera*), trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*). Willow (*Salix* spp.) and alder (*Alnus rugosa* and *A. crispa*) line edges of the lake and channel. Lake width at the study site is approximately 1 km and water depths are less than 6 m. Topography in this area is comprised of low relief hills. Exposed bedrock lines the lake and river shores. An area of open water, known locally as an *ashkui,* occurs here early in spring.

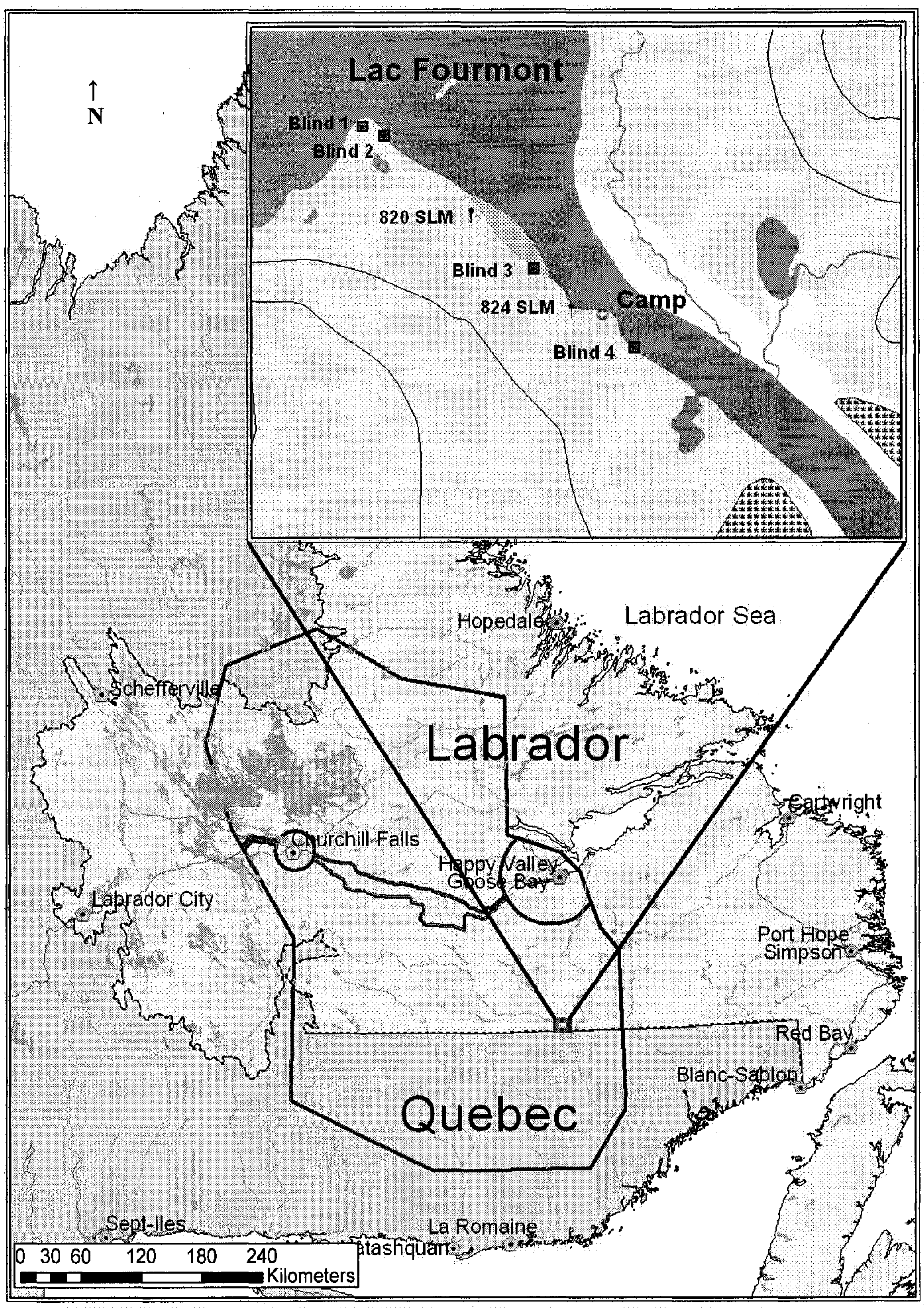

Figure 2.1: Location of study site at Lac Fourmont, Labrador, Canada. Black polygon indicates 130 000 km^2 Low Level Training Area. Inset shows location of camp, observation blinds and Sound Level Meters (SLM) as well as detail of surrounding topography.

MATERIALS AND METHODS

Weather Measurements

The following five weather parameters were recorded prior to each sampling period: cloud cover (%), temperature (°C), wind speed (km/hour), wind direction (by hand-held anemometer), and precipitation. Type of precipitation was recorded and categorized as light, moderate, or heavy. Daily weather summaries, with maximum and minimum temperatures and precipitation for Goose Bay, Labrador, were also obtained from Environment Canada (Anonymous 2002).

Behavioural Observations

Behavioural observations were made on three species which were selected on the basis of sample size. There were no marked birds. All birds were observed daily during each time period. Behaviour observed was categorized as indicated in Table 2.1.

Table 2.1: Behavioural categories of waterfowl activity recorded at Lac Fourmont *ashkui* 26 April- 27 May 2002 (after Jorde *et al.* 1984).

Behaviour	Description
AGONISM	Ranged from simple threat and avoidance postures to energetically costly chasing and pursuit flights
ALERT	Birds held their heads upright with necks outstretched. These birds were fully aware of their surroundings, watching and listening for potential disturbance, threats or predators.
COMFORT	All behaviour associated with body maintenance including *preen, splashbathe* and *wingflap* (McKinney 1965).
COURTSHIP	All behaviour associated with mate attraction and copulatory behaviours: further defined as *outside pair, within pair, and unknown* in which courtship behaviours are not directed at a particular bird.
LOCOMOTOR ACTIVITIES	All movement activities in water, on ice or in air including*: swim, scoot, fly,* and *walk.*
FEED	All activities associated with food acquisition including*: dive, pause, upend,* and *surface feed.* Birds sometimes swam short distances and immediately began feeding again. The time involved in changing location was coded as *locomotor activity.*
OUT OF SIGHT	Birds were occasionally hidden from view by ice or rocks for short periods of time. Calculations of percentage of time spent in various activities were based on the amount of time birds were actually observed.
REST	Not moving, in one spot yet not alert nor asleep.
SLEEP	Eyes closed with the head usually held close to the body or lying on the back with bill tucked into the feathers
STAND	On ice

Data Collection

Observations were conducted from raised camouflaged blinds that were constructed 5 days prior to data collection. Observers spent approximately 15 minutes in blinds prior to data collection. Observations were conducted with the aid of spotting telescopes (Swarovski Optik Habicht ST 80mm 20-60X magnification and Bausch and Lomb 45X60) from distances of 50-100 meters. Two researchers were stationed in each of two blinds during each sampling event: one making observations through a spotting scope and the other recording data. Daylight hours were divided into four sampling periods: 1 - dawn (0600-0900), 2 - morning (0900-1200), 3 - afternoon (1300-1600), and 4 - dusk (1700-2000 Atlantic Standard Time (AST)). Sampling effort was concentrated between 0900-1200 AST and 1300-1600 AST when military jet over-flights were most likely to occur. Observations were made using focal animal sampling for 5-minute intervals (Baldasarre *et al.* 1988; Lehner 1996). Observations commenced 26 April and concluded 27 May 2002. Dawn and dusk samplings of 1.5 h duration began on 27 April and were made seven and nine days, respectively, throughout the field season. Dawn surveys began 15 minutes prior to sunrise while dusk surveys ended 15 minutes after sunset (Appendix A). There were one or two active blinds during each of these times (Appendix B).

The species and sex of individual birds observed were chosen randomly. A flock was defined as a group of birds spatially distinct from other groups. A spotting scope was positioned on the flock and the bird closest to the center of view was chosen for observation. Data were recorded with handheld Psion® Data loggers using Observer© software.

Standardized Behavioural Categories

Activities were characterized into nine behavioural categories and modifiers were used to further sub-divide four of these, thus behaviours were classified using 23 categories in the field (Appendix C). However, activities were combined into 10 categories for analysis (Table 2.1). Activities identified in this paper were based on Jorde *et al.* (1984). *Bent-neck, head forward, head pumping* and *erect* activities associated with Canada Geese (Palmer 1976) were all considered agonistic behaviours. Although out of sight was considered a behavioural category, we noted when birds were lost from observation. Pair status was subjectively determined g proximity between males and females that exhibited courtship behaviours.

Statistical Analyses

SAS version 8.0 (Anonymous1999) was used for all statistical analyses. Normality could not be achieved with transformations. The variables time of day, observer, sex, pair status and wind direction were treated as categories while temperature, date, and wind speed were treated as covariates. Generalized Linear Modeling (GLM) of ranked variables was applied because we wished to analyze a number of variables simultaneously and to build more complex models than possible with non-parametric statistics. We conducted analyses of behaviour comparing among observers, sex, pair status, time of day, season and weather parameters. The chosen critical value of α was 0.05 and all tests were two-tailed.

RESULTS

Phenology

Average daily temperature during April-May 2002, was 4.1 °C and fell within a 5 °C range (4.0-9.0 °C) for the past decade indicating that weather was not atypical (Anonymous 2002). Birds were first observed staging at the Lac Fourmont *ashkui* in 2002 on 17 April.

When field observations commenced 26 April 2002 adjacent water bodies were completely frozen with the exception of the relatively small *ashkui* at the outlet of Lac Fourmont. Throughout the 32 day field season the ground was snow covered and surrounding lakes were ice covered. The field season ended on 27 May 2002 when the ice left Lac Fourmont through the channel to Lac Donquan.

Species Composition and Abundance

There were fourteen species of waterfowl on the *ashkui* throughout the 2002 field season (Figure 2.2; Appendix D). The peak day was 13 May when there was 376 individual waterfowl present (median flock size = 39 birds, range = 3 - 376). The peak days for diversity were 14, 20, 21 and 23 May when there were 11 species each day.

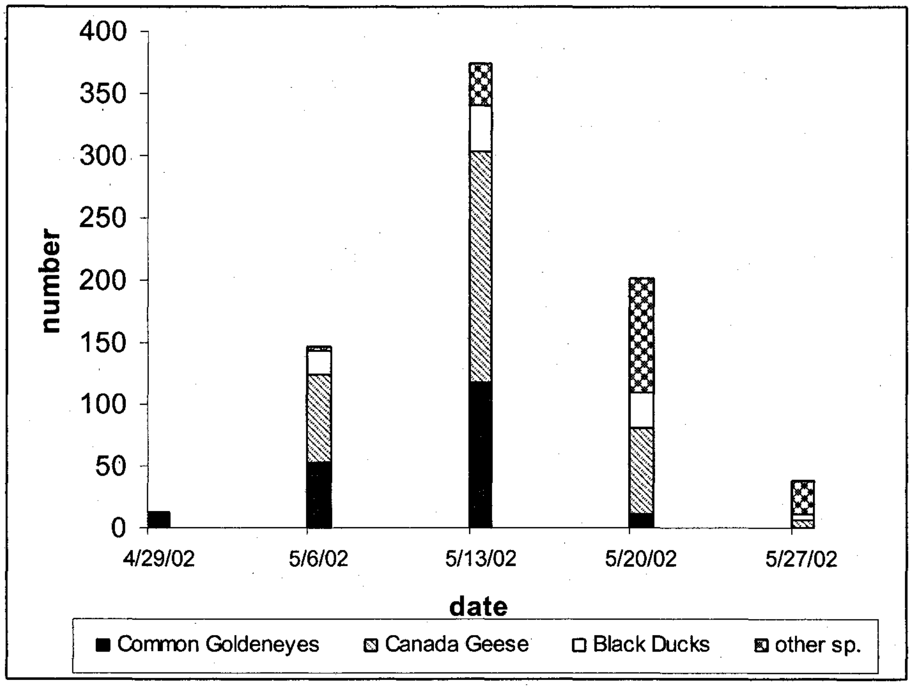

Figure 2.2: Changes in weekly number of Common Goldeneye, Canada Geese and Black Ducks at Lac Fourmont *ashkui*, Labrador April and May 2002

Time-Activity Budgets

Over 32 days 2594 5-minute focal individual (continuous) observations were recorded over a total of 216.17 hours, divided into the following time periods: period 1, n = 125 (10.42 hours), period 2, n = 1101 (91.75 hours), period 3, n = 1204 (100.33 hours), and period 4, n = 164 (13.67 hours). On two days (12 May and 26 May) observations were not recorded due to inclement weather and crew fatigue. Rarely were focal birds lost from sight: Canada Geese and Black Ducks (<1%); Common Goldeneye (1.42%).

Observer Effects

Only four observers collected data during a short field season dictated by a brief climatic window. Despite this, there were consistent statistically significant differences among observer records. Therefore, an observer effect was included in all analyses.

Canada Geese

We collected 62.58 hours (n= 751) of 5-minute focal observations on Canada Geese during spring 2002. Geese spent most (38%) of their time sleeping, followed by courtship (19%) and alert posture (19%). Little time (5%) was spent feeding and only rarely (0.24%) was agonistic behaviour observed(Figure 2.3).

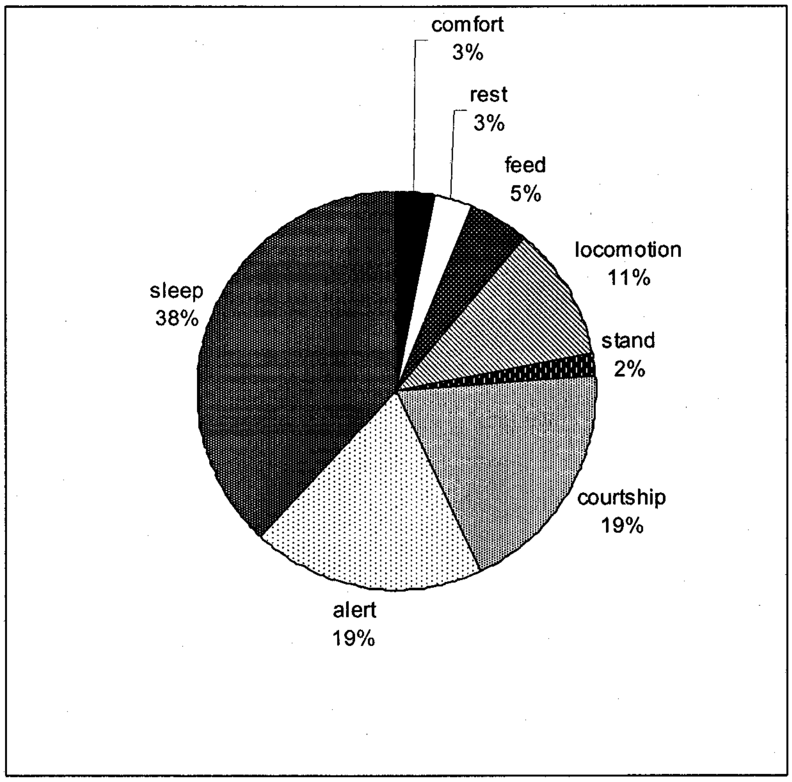

Figure 2.3: Diurnal (periods 1-4) time activity budget of spring-staging Canada Geese at Lac Fourmont *ashkui*, Labrador, Canada, 2002

Temperature, cloud cover, wind speed and wind direction did not play a significant role in Canada Goose TA budgets. However, cloud cover affected time spent in alert behaviours (F=5.00, df=1, 554, P=0.03). Geese spent less time in agonistic behaviours, comfort movements (F=4.46, df=1, 638, P=0.04) and courtship behaviours (F=4.52, df=1,638, P=0.03) as the percentage of cloud cover increased. Increasing wind speeds were associated with significantly increased amounts of time geese spent standing (F=7.76, df=1, 554, P=0.001). Westerly winds were associated with more agonistic (F=6.57, df=3, 554, P=0.0002) behaviours. Geese spent more time in locomotion (F=5.73, df=3, 554, P=0.0007) when winds came from the south. They spent more time sleeping (F=13.71, df=3, 554, P<0.0001) during easterly winds.

Comfort movements (F=3.97, df=3, 554 P=0.008), occurred more frequently (12%) during period 1 than at any other time of day (average 8.9%). Most feeding (F=3.17, df=3, 554, P=0.02) occurred during period 2 (10%) and was lowest (3.8%) during dusk (period 4). Highest locomotor activity (F=5.56, df=3, 554, P=0.0009) occurred during period 4 (59%) and least in period 1 (45%). Alert postures (F=6.11, df=3, 554, P=0.0004) were seen more during period 1 (31%) and less in period 4 (7%) (Figure 2.3).

Unpaired geese (12%) spent more time in comfort movements (F=3.33, df=1, 655, P=0.04) than did paired geese (8%). Paired birds (10.4%) spent, on average, more time in alert behaviours (F=9.47, df=1, 655, P<0.0001) than did unpaired birds (9%).

As the season progressed geese, spent less time in agonistic behaviours (F=9.01, df=1, 554, P=0.003), comfort movements (F=45.38, df=1, 554, P<0.0001), courtship displays (F=5.77, df=1, 554,P=0.02) and sleeping (F=24.63, df=1, 554, P<0.0001). Geese rested more (F=13.04, df=1, 554, P=0.0003) and were more alert (F=5.69, df=1, 554, P=0.02) towards the end of the spring-staging season.

Black Ducks

We collected 39.58 hours (n=475) of 5-minute focal observations on American Black Ducks during spring 2002. Black Ducks spent relatively little time feeding (12.4%) and greater than one third of the time sleeping (35%)(Figure 2.4). Locomotor activity comprised the largest component of the Black Duck TA budget with a mean of 37.8%, while <1% of their time was spent in courtship behaviours. Agonistic and courtship displays combined for <2% of the Black Duck TA budget.

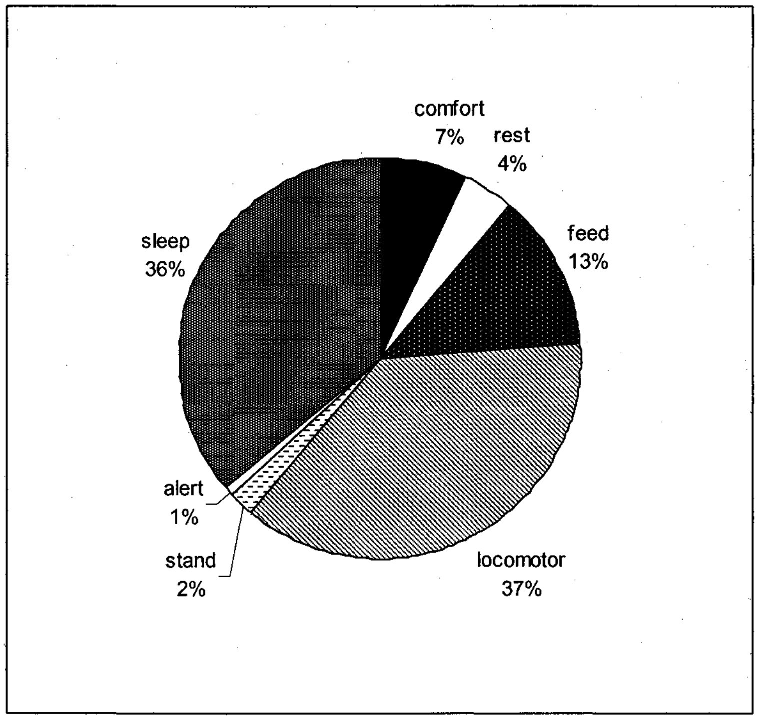

Figure 2.4: Diurnal (periods 1-4) time activity budget of spring-staging American Black Ducks at Lac Fourmont *ashkui*, Labrador, Canada, 2002

As cloud cover increased, Black Ducks spent less time moving (F=3.99, df=1, 260 P=0.05) and courting (F=4.6, df=1, 260 P=0.03). The amount of time spent feeding (F=9.84, df=1,289, P=0.0019) and in locomotor activities (F=7.51, df=1, 289, P=0.0065) increased, and the amount of time spent sleeping (F=13.35, df=1, 289, P=0.0003) decreased with an increase in wind speed. Wind direction did not affect behaviour.

Black Ducks spent more time standing (F=2.71, df=3, 289, P=0.05) during time period 1(3.3%) and least during time period 2 (1.2%).

Black Ducks generally spent time period 1 sleeping and time period 2 resting, courting and alert. During period 3 they fed, walked, swam and flew, and stood. The dominant behaviour exhibited in period 4 was comfort movements.

Paired Black Ducks (12.8%) spent less time feeding (F=4.46, df=1, 289, P=0.04) than unpaired birds (18.4%). Unpaired Black Ducks spent less time at rest (F=3.13, df=1, 289, P=0.08), sleep (F=2.44, df=1, 289, P=0.12) and in comfort movements (F=0.02, df=1, 289, P=0.90) than did paired birds.

Black Ducks exhibited fewer comfort movements (F=4.49, df=1, 289, P=0.03) as the season progressed. There were no other significant relationships with behaviour and time of year.

Common Goldeneyes

We collected 106 hours (n=1272; male n=845, female n=427) of 5-minute focal observations of Common Goldeneye during spring 2002 (Figure 2.5). Time-activity budgets for male and female spring-staging Common Goldeneye were very similar (Figure 2.5). Feeding was the predominant behaviour (55%). Agonistic behaviours and standing represented <1% of the diurnal TA budget.

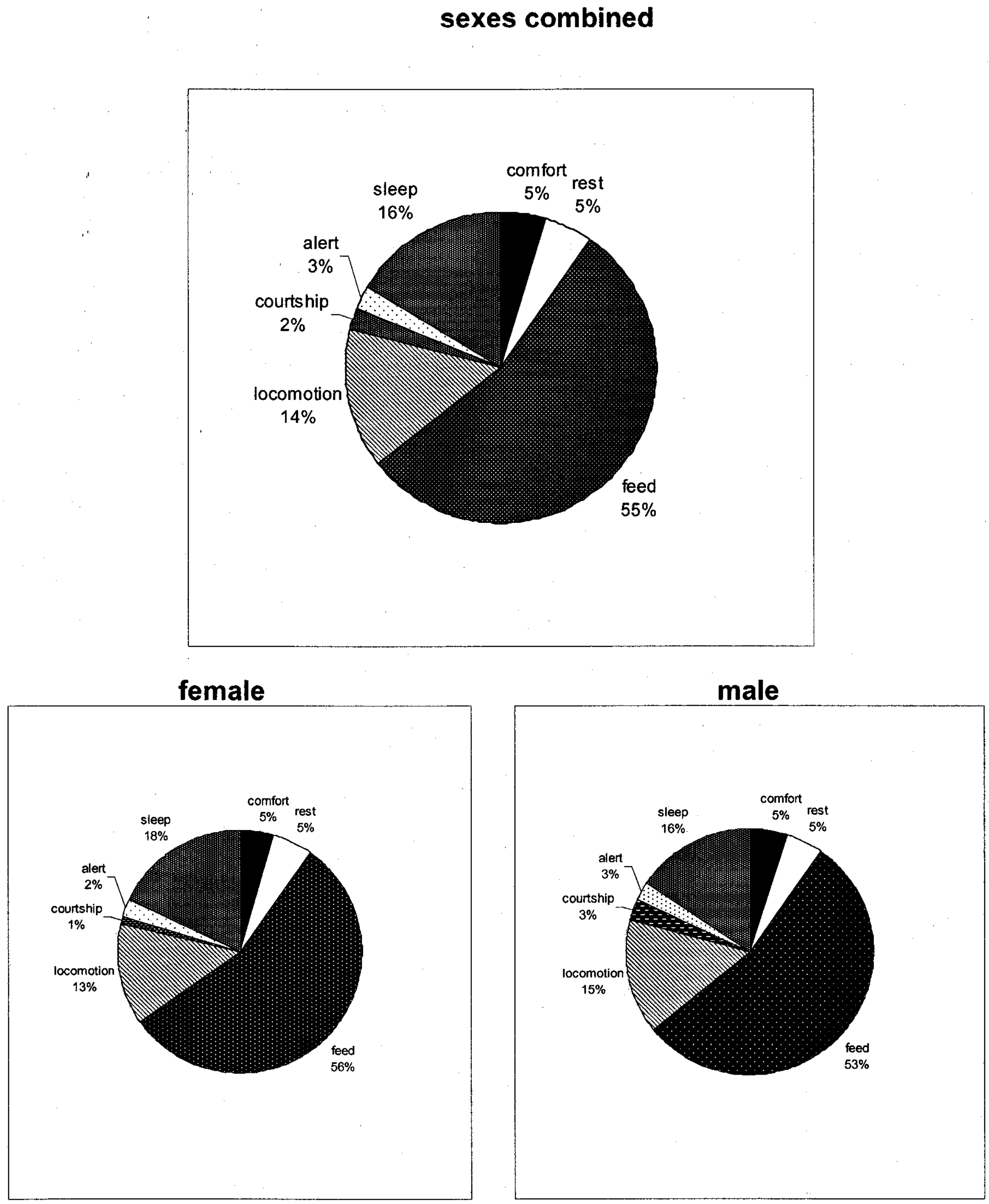

Figure 2.5: Diurnal (periods 1-4) time activity budget of spring-staging Common Goldeneyes at Lac Fourmont *ashkui*, Labrador, Canada, 2002

Goldeneyes slept more as temperatures increased (F=4.84, df=1, 449, P=0.03). As wind speed increased the amount of time exhibiting comfort postures (F=8.94, df=1, 449 397, P=0.0029), feeding (F=6.03, df=1, 449, P=0.01) and courtship (F= 6.52, df=1, 449, P=0.01) decreased. The time spent alert (F=27.34, df=1, 449, P<0.0001) increased with increased wind speed.

Feeding (F=5.71, df=3, 449, P=0.0008) and sleeping (F=2.67, df=3, 449, P=0.047) were behaviours affected by time of day. Feeding was highest (57%) and sleeping lowest (13%) in time period 2, while sleeping was highest (40%) and feeding lowest (28%) in time period 4.

Unpaired birds spent less time courting, alert and sleeping. Female Goldeneyes spent more time feeding and sleeping (56% and 18%, respectively) than males (53% and 15%, respectively). Male Common Goldeneye (2.7%) spent more time in courtship behaviours than female (1.1%) (F=18.6, df=1, 268, P<0.0001). Male and female Common Goldeneye TA budgets were dominated by feeding (53.3% and 54.5%), while they spent little time resting (4.8% and 5.2%). Males spent more time in locomotor activities and exhibiting agonistic behaviours than females.

There was a significant sex by pair status interaction related to the amount of time Common Goldeneyes spent in courtship behaviours (F=3.74, df=2, 449, P=0.02). Examined separately, males (26.7%) and unpaired males (31.3%) spent more time in courtship displays than did females (10.8%) and male-female pairs (30.2%).

Common Goldeneyes spent less time resting (F=5.72 df=1, 449, P=0.02) and more time alert (F=4.10, df=1, 449, P=0.04) as the season progressed.

Discussion

Sleeping was an important activity for Canada Geese (38%) and they also spent much of their diurnal TA budget in courtship (19%). Spring-staging Canada Geese are similar to wintering Canada Geese in that inactivity (including rest and sleep) is the dominant activity during the diurnal period, probably because other activities like feeding depend upon the disappearance of snow cover for this grazer. A study of wintering Canada Geese by Raveling *et al.* (1972) found that weather, particularly temperature, had an effect on behaviour. Weather at Lac Fourmont also affected behaviour of geese. Activity levels of Canada Geese at Lac Fourmont were affected by time of day as were wintering geese in mid-continental U.S.A. (Raveling *et al.* 1972). Spring-staging geese were more active (comfort movements and locomotor activities) during the cooler periods of the day likely in an effort to maintain body temperature. Otherwise, it seems that spring-staging geese avoid energy costly activities. The relatively short time spent feeding on the staging grounds suggests that the geese previously have acquired necessary nutrients for reproduction.

Sleeping (36%), locomotion (37%) and feeding (13%) were dominant activities for Black Ducks at Lac Fourmont *ashkui*. Our TA budget for Black Ducks differs little from what is found in the literature for this species and other dabblers during fall and winter, in that sleep/rest, locomotor activities and feeding are the three dominant activities (Hickey and Titman 1983; Jorde and Owen 1988; Conomy *et al.* 1998). The exception was that Black Ducks at Lac Fourmont spent relatively little time feeding (13%) in comparison with wintering

Black Ducks at Prince Edward Island (PEI). Hickey and Titman (1983) reported dominant activities in late winter at PEI as feeding (39.7%), resting (32.5%), and locomotor activity (11.9%). Similarly, Hepp (1982) reported the same two dominant activities (43% and 40%, respectively). At northerly latitudes, birds may conserve energy as well as preserve the insulating ability of plumage by spending more time resting during the day (West 1962; Paulus 1984, 1988). A peak of locomotor activity at dusk, as observed at Lac Fourmont, is typical of Black Ducks (Longcore *et al.* 2000). This dusk peak and the high percentage of time spent by Black Ducks in locomotion (37%) may have facilitated thermoregulation, a compensatory reaction (Albright 1981) to the relatively cool average daily temperature (4.1°C) recorded during spring-staging at Lac Fourmont.

Black Duck feeding peaked in the afternoon and was lowest in the dawn observation period. Black Ducks spent more time feeding as the season progressed. Food may have become available as Lac Fourmont started to warm up. This may be important in the boreal region where the breeding season is short. Black Ducks exhibited similar TA budgets to Canada Geese in that much time was spent sleeping and resting presumably waiting for food resources and breeding habitat to become available. This strategy implies that energy needed for breeding is either acquired on the wintering areas and brought north or it is acquired on the breeding grounds (Owen and Reinecke 1979, Raveling 1979; Krapu 1981).

In contrast to these two species, feeding was the dominant activity of Common Goldeneyes at Lac Fourmont ashkui (55%). This finding is similar to other studies of pre-breeding season (Nilsson 1970; Bergen *et al.* 1989; Eadie *et al.* 1995). Replenishing energy stores after migration and nutrient loading prior to egg-laying is a likely explanation. Sixteen per cent of their TA budget was spent sleeping. Unpaired Common Goldeneyes spent less time courting, alert and sleeping. Common Goldeneyes also spent more time in locomotion at dawn and dusk, when diurnal temperatures were coolest.

Ashkui are the only areas of open water at this time of year in this region. This study suggests that these spring-staging Common Goldeneyes are optimizing use of this highly productive site (Fletcher and Breeze 2000) for feeding while Black Ducks and Canada Geese use *ashkui* primarily for resting.

The close proximity of this productive area to their breeding grounds allows waterfowl to "wait out" the ice thaw while feeding, probably replenishing or conserving nutrient reserves. Canada Geese often migrate to breeding grounds before spring thaw has occurred (Raveling 1978), an adaptation where the breeding season is short. Canada Geese, Black Duck , Common Goldeneye also feed in and around their breeding grounds.

In conclusion, open water areas such as the Lac Fourmont *ashkui* are important sites for spring-staging waterfowl. This study site was used as a place close to the breeding grounds to wait out snow melt for Canada Geese and Black Ducks, and as a foraging site for Common Goldeneye.

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Connecting Text

In Chapter 2, factors influencing the time-activity budgets of spring-staging waterfowl in the boreal forest were described. We found that Canada Geese and Black Ducks use this site to rest and conserve energy close to the breeding grounds while Common Goldeneye used the site for feeding. Both resting for Canada Geese and Black Ducks and feeding for Goldeneye are important and disruptions in these activities will affect the energy reserves of the species. This understanding of spring-staging waterfowl behaviour and their time-activity budgets is necessary to assess the impact of low-level military jets on the behaviour of these birds. Chapter 3 identifies the impacts of low-level military jets on spring-staging waterfowl at this site in the eastern boreal forest.

CHAPTER 3: **Effect of low-level flying military aircraft on the behaviour of spring-staging waterfowl at Lac Fourmont *ashkui*, Labrador, Canada**

INTRODUCTION

Staging areas are a necessary component of waterfowl habitat and birds may return to the same staging areas year after year (Palmer 1976). Some species of waterfowl, such as Canada Geese (*Branta canadensis*), acquire most of their nutrients for reproduction while on wintering and/or staging areas prior to their arrival on the breeding grounds. Geese may time their arrival at the spring staging areas to coincide with the availability of forage. Time-activity (TA) budgets can be used to evaluate the effects of disturbance on behaviour. Staging prior to reaching the breeding grounds may be necessary to rebuild or maintain nutrient reserves of geese before the final leg of the trip (Raveling 1979). A failure to breed can be caused by unsuitable foraging on the staging and/or breeding grounds (Krapu and Reinecke 1992). These birds need to be at peak body condition upon arrival to meet the energetic needs of reproduction. The ability of migratory birds to store and utilize large amounts of fat has been known for some time (Odum 1960). Reserves provide energy for migration and reproduction and there is considerable evidence that food resources available to pre-breeding and breeding waterfowl influence reproductive performance in several ways: 1) timing of reproduction, 2) failure to breed, 3) clutch size, 4) egg mass and composition, 5) egg fertility and hatchability, and 6) occurrence and frequency of re-nesting (McLandress and Raveling 1981, Krapu and Reinecke 1992). It is believed that knowledge of potential dangers and local resources enhance survival and breeding potential (Black *et al.* 1991).

Geese, in general, are loyal to spring-staging grounds. The theory that knowledge of food and predator distribution are important determinants of site fidelity is one argument for repeated use of spring-staging grounds (Reed *et al.* 1998).

Aircraft noise is known to be a stressor of wildlife and can alter the behaviour of animals (Delaney *et al.* 1999; Ward *et al.* 1999). The noises generated by military aircraft are unique and therefore comparisons of effect of noise cannot be made with other aircraft or activity (Larkin *et al.* 1996).

Behavioural responses to noise may be immediate or long-term and include changes in feeding rates, increased levels of aggression, changes in home range size, escape/flight (leading to increased energy expenditure and accidents), avoidance (leading to reduced use or abandonment of habitat), and effects on reproductive activities (Larkin *et al.* 1996).

A response such as fleeing causes an increase in metabolic rate and therefore an increase in energy expenditure (Geist 1971a, b). In this way a detectable change in behaviour can be used to quantify disturbance. Thiessen *et al.* (1957) speculate that because waterfowl are hunted regularly and as migrants they may be unfamiliar with a particular disturbance, they are more overtly responsive to noise than other birds. Particularly costly is a notable reduction in time spent foraging. Animals that engage in energetically costly activities, such as migratory flight, may notice any disruption to feeding activity which may be detrimental to the energy balance of these animals (Bélanger and Bédard 1990; Tyler 1991).

There has been little research on staging waterfowl (Madsen 1985; Bélanger and Bédard 1989). Geese may be more sensitive to noise, such as that from an aircraft disturbance, during staging than during other periods of the year (Gollop *et al.* 1974; Salter and Davis 1974; Barry and Spencer 1976; Bélanger and Bédard 1989). Bélanger and Bédard (1989) found that Greater Snow Geese (*Anser caerulescens*) staging along the St. Lawrence River were disturbed most often by transport activities (including aircraft over-flights) in the spring. This type of disturbance resulted in geese spending more time in flight (x =109.7 sec) versus a hunting disturbance which caused them to take flight for approximately 50 sec. Owens (1977) found that Brent Geese (*Branta bernicla*) habituated slowly to low-flying (<500 m altitude and up to 1.5 km distant) aircraft and almost always took flight when this type of disturbance occurred. Being over-flown by aircraft during spring-staging may result in separation of members of a pair (Mackenzie 1976).

Waterfowl concentrate at *ashkui* during spring-staging when low-level over-flight training occur within the Low Level Training Area (LLTA). This is the first study of staging Canada Geese, Black Ducks (*Anas rubripes*) or Common Goldeneyes (*Bucephala clangula*) in Labrador or anywhere at this latitude within the boreal forest.

Our objective was to determine behavioural responses of spring-staging waterfowl to jet over-flights. Behavioural observations provided information on the sensitivity of these species to aircraft over-flights. We further aimed to determine whether a military training flights affected short-term habitat use by staging waterfowl at this particular site. A secondary objective was to assess the flight safety hazard to jet pilots as a result of overt behavioural responses of spring-staging.

The null hypothesis is that waterfowl do not exhibit overt behavioural responses to low-level military jet aircraft noise.

STUDY AREA

Low-level Training Area

The LLTA (130 000 km^2) of the Quebec-Labrador Peninsula covers a large portion of central and south-central Labrador and extends into eastern portions of Québec. This Training Area is situated in the northern extent of the eastern boreal forest (Figure 3.1). The LLTA is comprised of many habitats and is dissected laterally by the Churchill River Valley. Much of the landscape is characterized by open conifer-lichen forest (predominantly stunted black spruce, *Picea mariana*). Many large water bodies and string bogs dot the landscape, with tundra vegetation covering the higher elevations. The training area is sparsely populated and contains no permanent settlements.

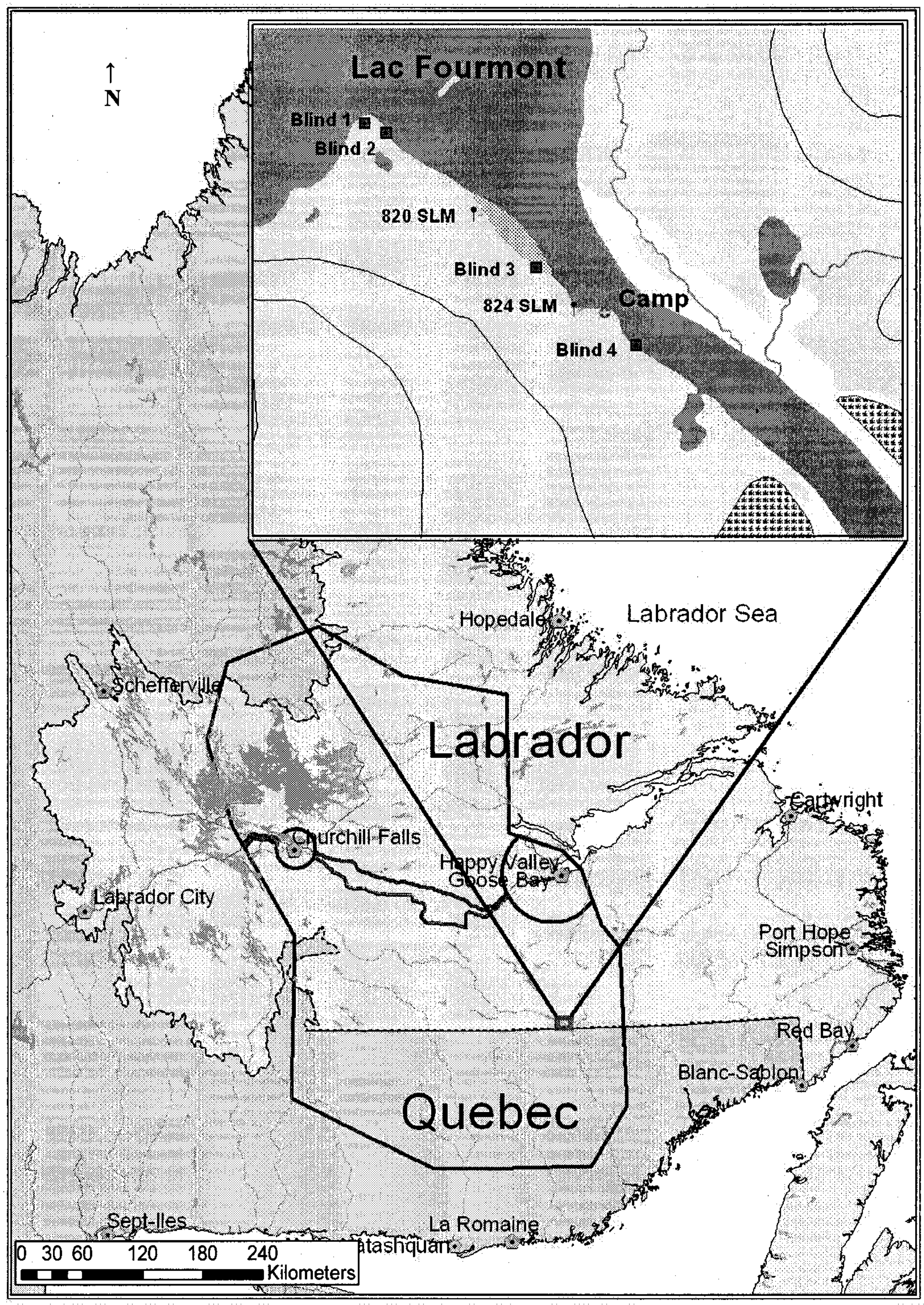


Figure 3.1: Location of study site at Lac Fourmont, Labrador, Canada. Black polygon indicates 130 000 km^2 Low Level Training Area. Inset shows location of camp, observation blinds and Sound Level Meters (SLM) as well as detail of surrounding topography.

There were approximately 6,000 sorties here annually, a majority of which occurred at low-level. Low-level flying is defined as less than 333 m above ground level (AGL) or water and is normally only authorized for weather avoidance. The sorties generally occurred most frequently in river valleys with >90% occurring during the daytime. The average altitude for low-level flights is 100 m AGL.

Lac Fourmont *Ashkui*

The study area was Lac Fourmont, Labrador (52° 03' 30" N, 60° 31' 01" W; Figure 1.1), a freshwater lake approximately 180 km south of Goose Bay, and well within the confines of the LLTA. It lies within the Low Subarctic Forest – Mecatina River Ecoregion as identified by Meades (1990). Lac Fourmont forms a part of the Little Mecatina watershed. This largely forested area is comprised of black spruce (*Picea mariana*) and balsam fir (*Abies balsamea*). Interspersed are small numbers of balsam poplar (*Populus balsamifera*), trembling aspen (*Populus tremuloides*) and white birch (*Betula papyrifera*). Willow (*Salix* spp.) and alder (*Alnus rugosa* and *A. crispa*) line the edges of the lake and channel. The width of the lake at the study site is approximately one kilometer and its depth is relatively shallow (< 6 m). Topography is characterized by low relief hills. Exposed bedrock lines the lake and river shores. An area of open water, known locally as an *ashkui,* occurs early in spring. The *ashkui* was located at a constriction in Lac Fourmont and extended through the narrows to Lac Donquan.

Lac Fourmont was chosen because: 1) Innu use the *ashkui* as traditional spring hunting grounds for waterfowl); 2) Aerial surveys carried out by the Canadian Wildlife Service in the spring of 2000 and 2001 indicate that a variety of waterfowl stage at the *ashkui* (Turner and Chaulk 2000). The topography of the region is suitable for low-level flight training and repeated and direct over-flights occur at Lac Fourmont.

MATERIALS AND METHODS

Weather Measurements

Prior to each sampling period: cloud cover (%), temperature (°C), wind speed (km/hour), wind direction (Nielsen-Kellerman Kestrel 4000™ hand-held anemometer), and precipitation were recorded. Type of precipitation (rain or snow) was categorized as light, moderate, or heavy. Daily weather summaries with maximum-minimum temperatures and precipitation for Goose Bay, Labrador (the nearest community approximately 180 km north), were obtained from Environment Canada (Anonymous 2002). Observations of waterfowl were conducted in all weather conditions.

Noise Measurements

Prior to the research period commencing on 17 April 2002, two Sound Level Meters were erected and programmed at the Lac Fourmont *ashkui*. A pilot flew designated flight paths in an F16 jet aircraft at predetermined altitudes and distances from the Sound Level Meters (SLM). This information was used by

Neil Standen (Urban Aerodynamics Ltd.) to create a sound model. This model was then used to give signature noise levels for jet aircraft that flew over during the research period.

Sound levels were measured so that noise events could be paired with observational data. Two Sound Level Meters (SLM) recorded data at the study site for the duration of the 2002 field season (n=336 hours of noise data). Larson-Davis SLM model 824, situated near blind 1 at 60° 32' 81" W, 52° 04' 28" N, recorded data from 21 April but was damaged and failed on19 May (Figure 3.2). Larson-Davis SLM model 820 was located approximately half way between blind 1 and camp at 60° 30' 09" W, 52° 01' 84"N. Model 824 was moved to a cove at 60° 29' 51"W, 52° 02' 71"N (approximately 50 m from waterfowl on the *ashkui*) and recorded data from 21 April – 9 May. Both SLM's were programmed to record data every second for seven hours/day (0900-1600 AST) in an effort to encompass military jet over-flights. They were programmed with a resolution of 0.1 dB and a recording interval of 30 minutes (*i.e.* mean values were calculated every 30 minutes). Many parameters were recorded but those of interest were L_{max} (maximum noise level at the SLM in dB), duration of the flight (seconds), onset rate of the noise as the aircraft approached the SLM, and the Sound Energy Level (SEL) or total noise dosage.

The field crew received an over-flight forecast daily from the Military Control Centre (MCC) at 5 Wing Goose Bay via satellite phone. As a result numbers, types and over-flight times of jet aircraft could be anticipated. Behavioural observations were made before, during and after over-flight disturbances. There were 91 jet over-flights at Lac Fourmont *ashkui* largely due to co-ordination with the Military Coordination Centre at 5 Wing Goose Bay, Department of National Defence.

Behavioural Observations

Behavioural observations were made on unmarked Canada Geese (n= 751), Black Ducks (n=475) and Common Goldeneyes (n=1276), the most common waterfowl. An effort was made to observe all three species representing geese, dabblers and divers on each day during each time period as described below. There were 8 other species present in smaller numbers at the study site during the field season, however effort was concentrated on the three target species.

Observations were conducted from elevated plywood platform blinds. In an effort to minimize disturbance, blinds were constructed 5 days prior to the start of data collection. Observers waited approximately 15 minutes after arrival at a blind before beginning observation. Observations were made using two spotting telescopes (Swarovski Optik Habicht ST 80mm 20-60X magnification and Bausch and Lomb 45X60) from distances of 50-100m. Two observers were stationed at each of two blinds during each sampling event; one made observations and the other recorded data. Daylight hours were divided into four sampling periods: period 1 - dawn (0600-0900), period 2 - morning (0900-1200), period 3 - afternoon 1300-1600), and period 4 - dusk (1700-2000 - Atlantic

Standard Time (AST)). Sampling effort was concentrated between 0900-1200 AST and 1300-1600 AST when military jet over-flights were most likely to occur. Focal animal sampling (continuous) was used for five-minute periods (Baldasarre *et al.* 1988; Lehner 1996). Observations commenced 26 April 2002 and concluded 27 May 2002. During two days (12 May and 26 May) there were no observations due to inclement weather and crew fatigue. Dawn and dusk samplings of 1.5 hours began on 27 April and were made on seven and nine days respectively spread randomly through the field season. Dawn surveys began 15 minutes prior to sunrise while dusk surveys ended 15 minutes after sunset (Appendix A). There were one or two active blinds during each of these times (Appendix B).

Individual birds, independent of species and sex were chosen randomly. The selection of the species to be observed was also based on representation of different taxa (i.e.dabbling ducks, diving ducks and geese). A flock was defined as a spatially distinct group of birds. A spotting scope was positioned on the flock and bird closest to center of view was chosen. Data recorders (Psion® Data loggers using Observer© software) were used. Researchers used topographical maps to indicated flight paths, over-flight times and type of aircraft.

Standardized Behavioural Categories

Time spent at each activity was measured to calculate time-activity budgets. Waterfowl activities were characterized into nine behavioural categories and modifiers were used to further sub-divide four of these categories, giving a total of 23 categories in the field (Table 3.1). However, activities were combined using only 10 categories for analyses based on Jorde *et al.* (1984). *Bent-neck, head forward, head pumping* and *erect* are postures and activities associated with Canada Geese (Palmer 1976) and were all considered agonistic behaviours (Appendix C).

Table 3.1: Behavioural categories of waterfowl activity recorded at Lac Fourmont *ashkui* 26 April- 27 May 2002 after Jorde *et al.* 1984).

Behaviour	Description
AGONISM	Ranged from simple threat and avoidance postures to energetically costly chasing and pursuit flights
ALERT	Birds held their heads upright with necks outstretched. These birds were fully aware of their surroundings, watching and listening for potential disturbance, threats or predators.
COMFORT	All behaviour associated with body maintenance including *preen, splashbathe* and *wingflap* (McKinney 1965).
COURTSHIP	All behaviour associated with mate attraction and copulatory behaviours: further defined as *outside pair, within pair, and unknown* in which courtship behaviours are not directed at a particular bird.
LOCOMOTOR ACTIVITIES	All movement activities in water, on ice or in air including*: swim, scoot, fly,* and *walk.*
FEED	All activities associated with food acquisition including*: dive, pause, upend,* and *surface feed.* Birds sometimes swam short distances and immediately began feeding again. The time involved in changing location was coded as *locomotor activity.*
OUT OF SIGHT	Birds were occasionally hidden from view by ice or rocks for short periods of time. Calculations of percentage of time spent in various activities were based on the amount of time birds were actually observed.
REST	Not moving, in one spot yet not alert nor asleep.
SLEEP	Eyes closed with the head usually held close to the body or lying on the back with bill tucked into the feathers
STAND	On ice

Statistical Analyses

SAS version 8.0 was used for all statistical analyses (Anonymous, 1999). Normality could not be achieved with transformations, so Generalized Linear Modeling (GLM) of ranked variables (to build more complicated models) was applied because we wished to analyze a number of variables simultaneously and to build more complex models than those available with non-parametric statistics. Only periods 2 and 3 were used for analyses since these were the periods when military flight activity occurred. Observations were classified following the over flight into 15-minute periods with all behavioural observations being assigned to their respective quarter hour periods up to 165 minutes after an over-flight. Each period was analyzed independently as a category and compared with the observations occurring before over flights began. To examine possible effects of sound levels on behaviour of waterfowl, a multiple regression technique was employed. Both sound level (Lmax) and time since the over-flight occurred were included as covariates, with proportion of time in each behaviour as the response. Time since over-flight was included to control for the time delay between the birds subjected to the noise event.

Bonferroni adjustments were not used as they increase the risk of making Type I errors. In resource management it is generally worse to miss impacts that may be there (commit Type II errors) than to identify impacts that may only be occurring by chance. Paired tests were run instead of regressions because threshold effects, not linear responses were expected. I not only looked at P-values and the magnitude of change were examined.

RESULTS

Phenology

The daily average temperature during April-May 2002, was 4.1 °C and fell within the 5 °C range (4.0-9.0 °C) for the past decade indicating that weather was typical (Anonymous, 2002). Birds were first observed staging at the Lac Fourmont *ashkui* in 2002 on 17 April.

When field observations commenced 26 April 2002, adjacent water bodies were completely frozen with the exception of the relatively small *ashkui* at the outlet of Lac Fourmont. Throughout the 32 day field season the ground was snow covered and surrounding lakes were ice covered. The length of the field season was weather dependent determined by condition of the *ashkui* (*i.e.* when open water was confined to the *ashkui*). As days became longer and temperatures warmer the *ashkui* expanded when by 27 May 2002 there was much open water at the outlet of Lac Fourmont and ice flowed through the channel to Lac Donquan.

Species Composition and Abundance

Fourteen species of waterfowl were observed staging on the *ashkui* throughout the 2002 field season (Appendix D). The peak day for waterfowl abundance was 13 May when approximately 376 individuals were present. Peak days for waterfowl diversity were 14, 20, 21, and 23 May with 11 species represented on each of these dates (median flock size = 39 birds, range = 3 to 376).

Over-flights and Noise Measurements

Eighty of 91 military over-flights occurred during our behavioural observations (26 April-27 May 2002). Aircraft types included F16 and F4 jet fighters. In addition there were two over-flights by Transals (military transport aircraft). Flight track distances from the *ashkui* varied from approximately 50 to1000 meters. Over-flights were concentrated between 0845h and 1700h from 26 April to 14 May and from 24 May to 27 May 2002. Daily average L_{eq} was 56.4 dB. The maximum noise (LMax) measured was 118.6 dB (Table 3.2) and was associated with an F16 jet over-flight at less than 10 meters above the water surface.

Table 3.2: Descriptive statistics for noise events (N=91) associated with low-level jet aircraft at Lac Fourmont *ashkui*, Labrador, Canada 26 April-27 May 2002. LMax=maximum (time averaged) noise level; SE=standard error;SEL=sound exposure level)

Parameter	N	Mean	SE	Min	Max
LMax (dB)	91	96.7	1.6	65.0	118.6
Onset rate (sec)	91	3.1	0.3	0.1	9.8
Duration (sec)	91	39.1	2.2	6.8	63.2
SEL (dB)	91	117.3	1.5	85.9	123.9

Effect of Low-Level Military Jet Aircraft

In many cases there was no apparent reaction to an over-flight but there were several occasions (9%) when, waterfowl flushed in response to them (Figure 3.2).

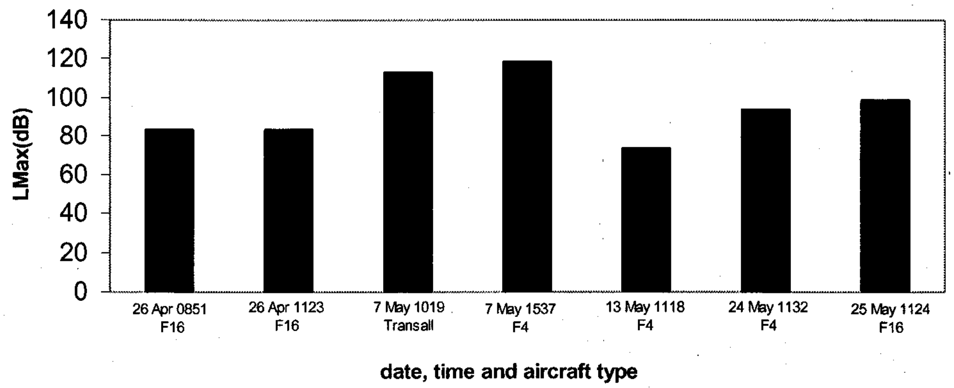


Figure 3.2: Sound levels at which waterfowl took flight in response to military over-flights at Lac Fourmont, Labrador during spring 2002

With many over-flights, the field crew made general notes about flock behaviour in addition to the behavioural observations of focal birds recorded on the data loggers. The flushing response varied, influenced by flock size, species present, date and noise intensity of the disturbance. Flushing altitude was not estimated. In some instances the flock returned and within one minute resumed the activity that it was engaged in prior to the disturbance. Other over-flights resulted in the flock flying about for up to four minutes before resuming normal activity. There were also agitated fast swimming and apparent diving responses noted during military over-flights. Similar waterfowl behavioural responses were noted in the presence of snowmobiles and predators (e.g. river otter, *Lutra canadensis*; bald eagle, *Haliaeetus leucocephalus)*.

Canada Geese

Courtship and alert behaviours increased immediately after an over-flight occurred (Table 3.3). A general agitation of geese immediately after over-flight followed by a settling down approximately 45 minutes post over-flight with increases in comfort, resting and then sleeping can be seen. There were no statistically significant effects detected on any behaviour 90 minutes after an over-flight.

The significant increase in mean time Canada Geese spent alert up to 60 minutes following a low-level over-flight and other details are clearly depicted in Figure 3.3.

There were no significant relationships between behaviour and noise level of the aircraft.

Table 3.3: Effect of military jet over-flights on the behaviour of spring-staging Canada Geese at Lac Fourmont *ashkui*, Labrador, Canada (ANOVA, P<0.05) ns = not significant

time after over-flight/ behaviour	0-15 min. (df=1, 509]	15-30 min (df=1, 482)	30-45 min. (df=1, 483)	45-60 min. (df=1, 475)	60-75 min. (df=1, 475)	75-90 min. (df=1, 474)	90-105 min. (df=1, 468)	105-120 min. (df=1, 467)	120-135 min. (df=1, 470)
agonism	ns	ns	ns	ns	ns	ns	ns	ns	ns
alert	F=4.20 P=0.04	F=8.52 P=0.004	ns	F=4.05 P=0.04	ns	ns	ns	ns	ns
comfort	ns	Ns	ns	F=4.90 P=0.03	F=4.16 P=0.04	F=12.43 P=0.0005	ns	ns	ns
courtship	F=3.88 P=0.05	F=5.95 P=0.02	ns	ns	ns	ns	ns	ns	ns
feeding	F=4.84 P=0.03	ns	ns	ns	ns	F=3.91 P=0.05	ns	ns	ns
locomotor	ns	ns	ns	F=4.00 P=0.05	F=9.19 P=0.003	F=3.91 P=0.05	ns	ns	ns
resting	ns	ns	ns	F=12.77 P=0.0004	ns	ns	ns	ns	ns
sleeping	ns	ns	ns	ns	F=12.16 P=0.0005	F=9.19 P=0.003	ns	ns	ns
standing	ns	ns	ns	ns	ns	ns	ns	ns	ns

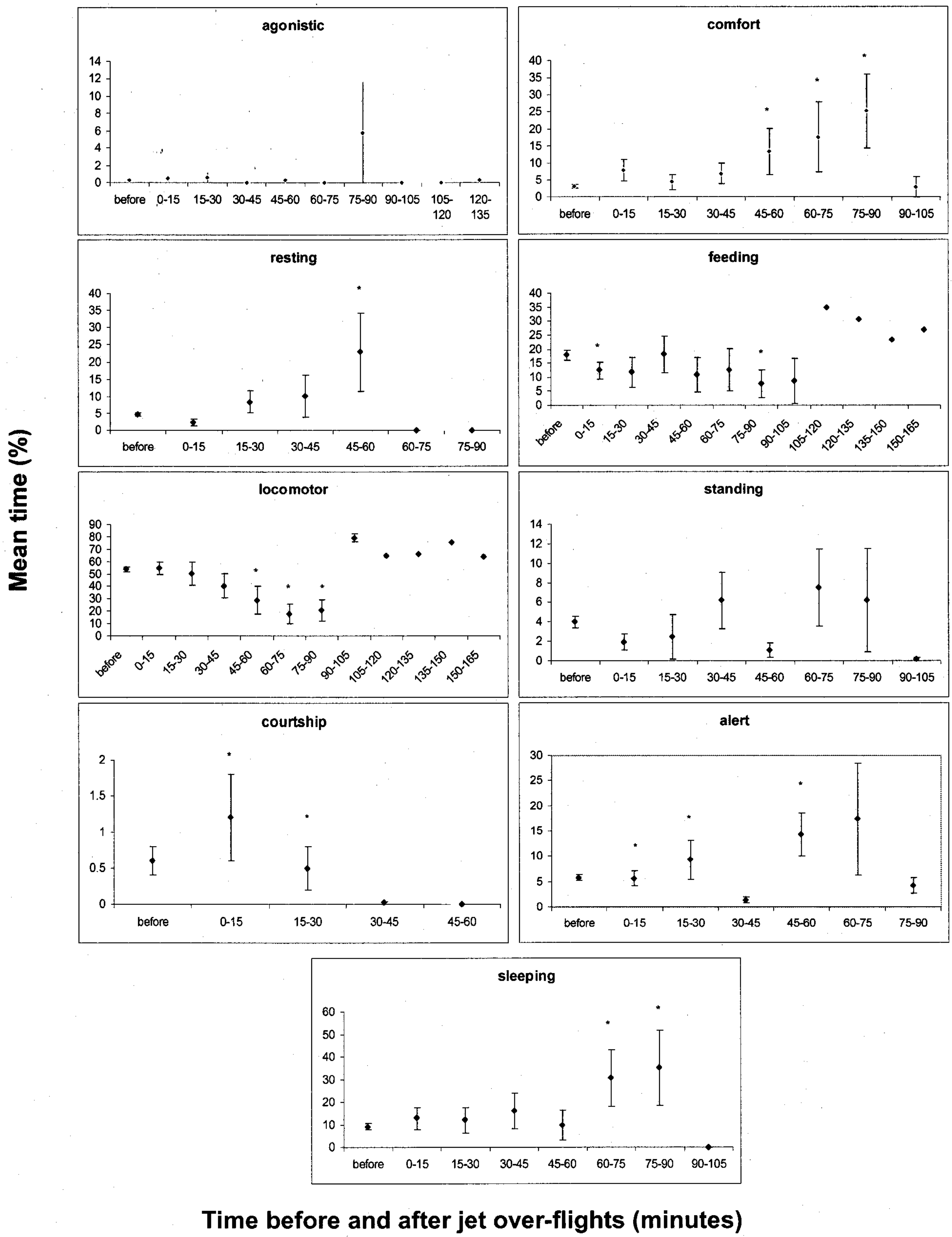


Figure 3.3: Effect of military jet over-flights on the behaviour of Canada Geese at Lac Fourmont *ashkui*, Labrador, Canada. Asterisk indicates statistical significance (α=0.05).

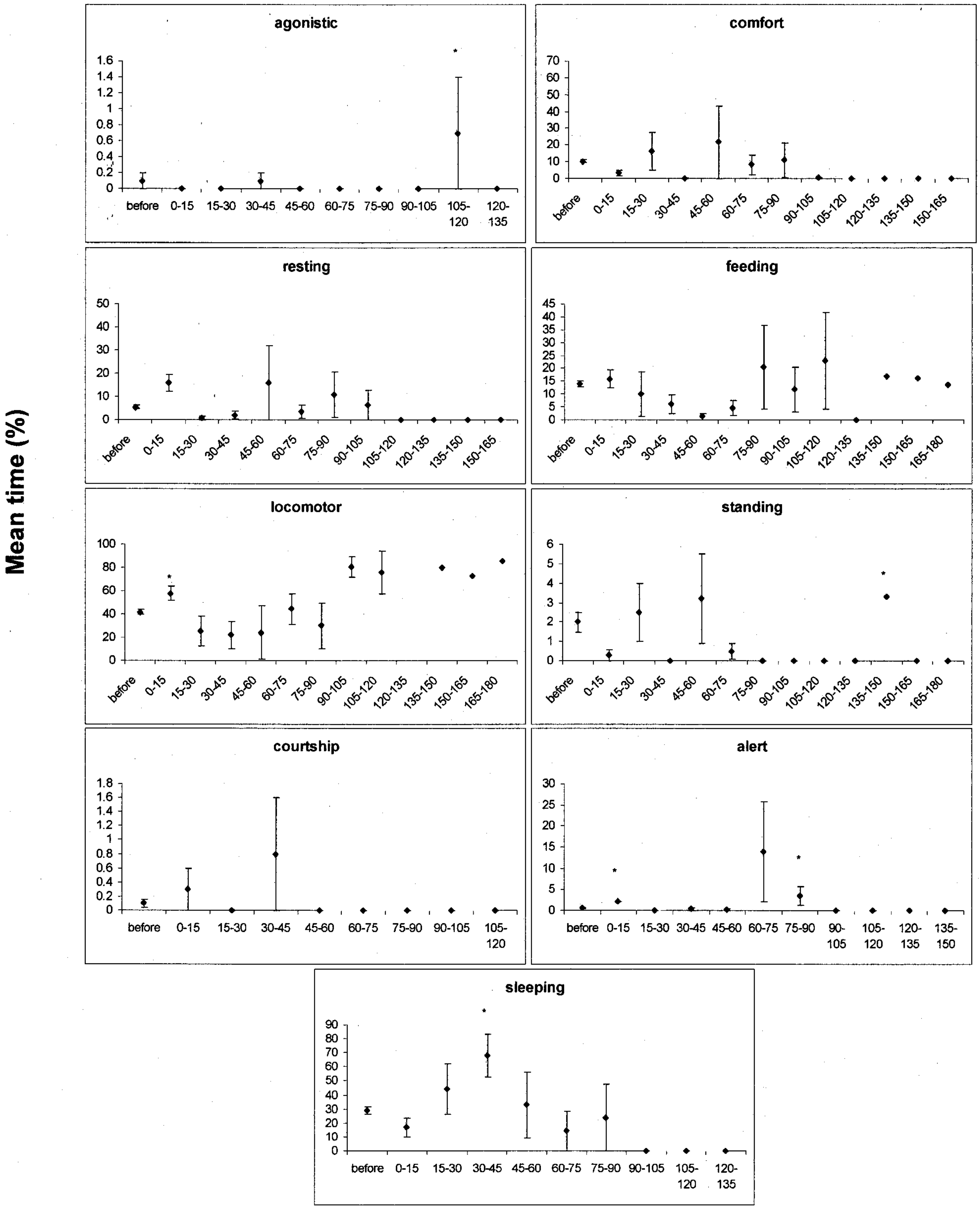
Black Ducks

Black Ducks generally showed less reaction to low-level jet aircraft noise than the geese. These ducks reacted initially to low-level jet aircraft noise by increasing alert and locomotor activities (Table 3.4). Agonism, sleeping and standing showed significant increases for short periods up to 180 minutes after a low level over-flight. These latter results may not follow meaningful pattern.

Locomotor activities by Black Ducks increased significantly in the first 15 minutes after a low-level over-flight (Figure 3.4). Multiple regression analyses showed that Black Ducks had a stronger movement response when the over-flight was noisier. (ANOVA, N=59, df=1, p=0.0148)

Table 3.4: Effect of military jet over-flights on the behaviour of spring-staging Black Ducks at Lac Fourmont *ashkui*, Labrador, Canada (ANOVA, P<0.05) ns = not significant; insufficient data for the 120-135 min. interval

time after over-flight/ behaviour	0-15 min. (df=1, 316)	15-30 min. (df=1, 300)	30-45 min. (df=1, 301)	45-60 min. (df=1, 295)	60-75 min. (df=1, 298)	75-90 min. (df=1, 295)	90-105 min. (df=1, 294)	105-120 min. (df=1, 294)	135-150 min. (df=1, 292)	150-165 min. (df=1, 292)	165-180 min. (df=1, 292)
agonism	ns	ns	ns	ns	ns	ns	ns	F=7.15 P=0.008	ns	ns	ns
alert	F=17.28 P<0.0001	ns	ns	ns	ns	F=3.90 P=0.05	ns	ns	ns	ns	F=6.64 P=0.01
comfort	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
courtship	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
locomotor	F=4.38 P=0.04	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
feeding	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
resting	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
sleeping	ns	ns	F=7.07 P=0.008	ns	ns	ns	ns	ns	ns	ns	ns
standing	ns	ns	ns	ns	ns	ns	ns	ns	F=5.01 P=0.03	ns	ns



Time before and after jet over-flights (minutes)

Figure 3.4: Effect of military jet over-flights on the behaviour of spring staging Black Ducks at Lac Fourmont ashkui, Labrador Canada. Asterisk indicates statistical significance (α=0.05)

Common Goldeneyes

Similar to Black Ducks, Common Goldeneyes react in the first 15 minutes following a low-level jet aircraft noise with a significant increase in the amount of time spent in agonistic and comfort behaviours (Table 3.5). There were also short duration increases in courtship (0.6% at 45-60 min.; 20.9% at 120-135 min.) and standing (<1%) for up to 105 minutes after the noise event. Again, these latter results may not be indicative of reactions due to low-level aircraft noise. Feeding, the most important behaviour for this species is not impacted by the jets at all.

Table 3.5: Effect of military jet over-flights on the behaviour of spring-staging Common Goldeneyes at Lac Fourmont *ashkui*, Labrador, Canada (ANOVA, P<0.05) ns = not significant

Time after over-flight/ behaviour	0-15 min. (df=1, 964)	15-30 min. (df=1, 932)	30-45 min. (df=1, 912)	45-60 min. **(df=1, 900)**	60-75 min. (df=1, 892)	75-90 min. (df=1, 889)	90-105min. **(df=1, 881)**	105-120 min. (df=1, 880)	120-135 min. **(df=1, 877)**
agonism	F=4.70 P=0.03	ns	Ns	ns	ns	ns	ns	ns	ns
Alert	ns	ns	ns	ns	ns	ns	ns	ns	ns
comfort	F=4.82 P=0.03	ns	ns	ns	ns	ns	ns	ns	ns
courtship	ns	ns	ns	F=6.27 P=0.01	ns	ns	ns	ns	F=4.71 P=0.03
locomotor	ns	ns	ns	ns	ns	ns	ns	ns	ns
feeding	ns	ns	ns	ns	ns	ns	ns	ns	ns
resting	ns	ns	ns	ns	ns	ns	ns	ns	ns
sleeping	ns	Ns	ns	ns	ns	ns	ns	ns	ns
standing	ns	Ns	ns	ns	ns	ns	F=10.86 P=0.001	ns	ns

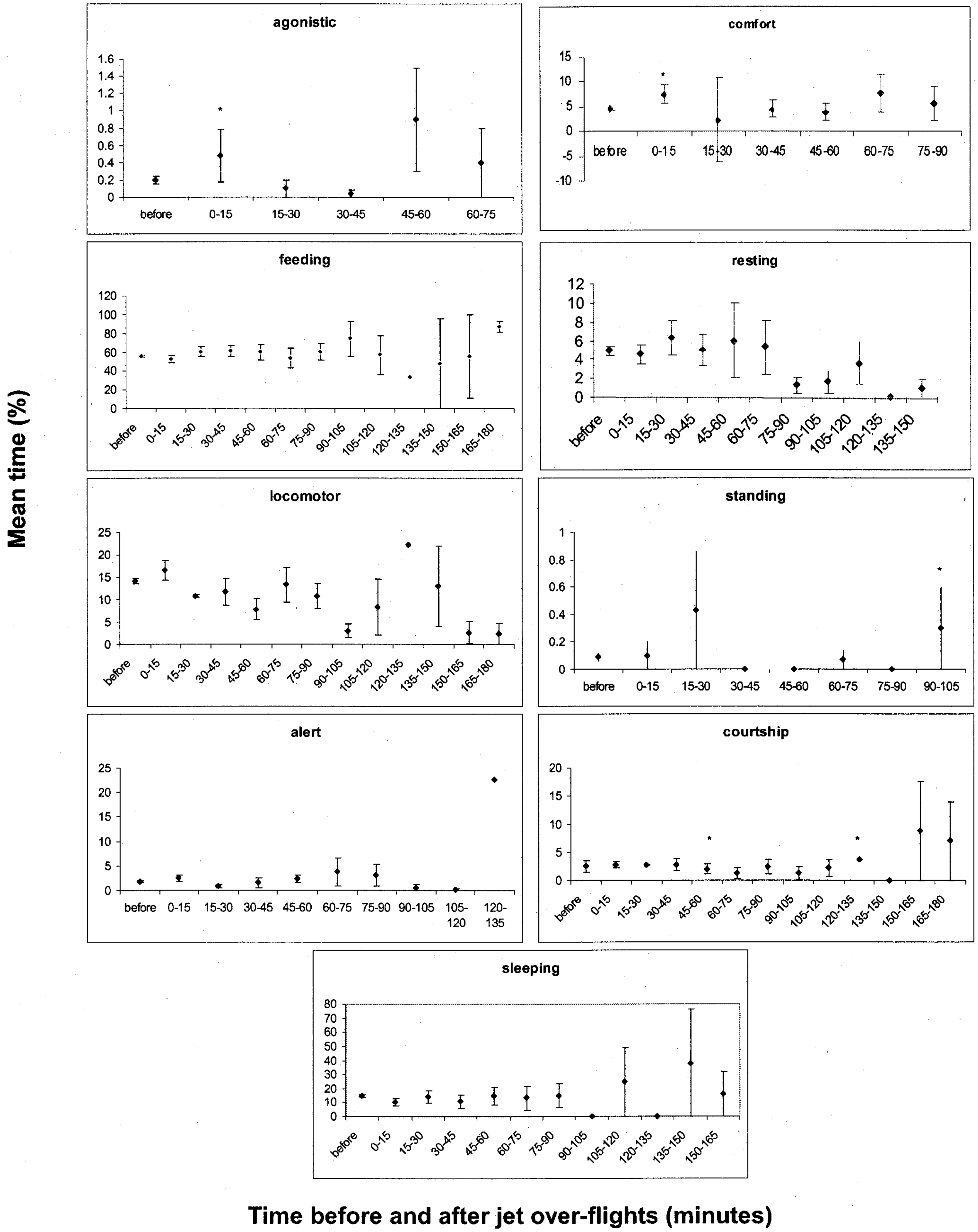


Figure 3.5 : Effect of military jet over-flights on the behaviour of spring-staging Common Goldeneyes at Lac Fourmont *ashkui*, Labrador, Canada. Asterisk indicates statistical significance (α=0.05).

DISCUSSION

Short term behavioural responses to low-level military aircraft were detected in spring-staging Canada Geese, Black Ducks and Common Goldeneyes. Decreases in time spent resting and sleeping which are energy-conserving activities, following a disturbance, as found with Canada Geese and Black Ducks at Lac Fourmont *ashkui*, may be indicative of increased energetic costs (Wooley and Owen 1978). An increase in comfort movement results in higher energy expenditure and a flushing response is a very energetically costly reaction to disturbance (Conomy *et al.* 1998). Canada Geese and Common Goldeneyes increased amounts of time they spent alert as the season progressed (Chapter 2). An alert response may be exhibited following a disturbance reflecting an individual's readiness to respond (Delaney *et al.* 1999). Canada Geese at Lac Fourmont appeared to change their behaviour more than the ducks we observed.

This study suggests little significant change in behaviour with the presence of low-level military over-flights. However, it is known that if waterfowl repeatedly alter activities so that less time is spent feeding or in energy-conserving activity in reaction to disturbance and alternatively partake in more energetically demanding activities, such as flight, the disturbance can be detrimental. Such a pattern creates a more expensive TA budget and by reduces fat storage for breeding (Bélanger and Bédard 1989). These responses may impact negatively on reproductive success by influencing female body condition which can affect continued migration, egg laying and brood rearing. To compensate for the increased energetic demands associated with responding to a disturbance, birds must increase food intake during undisturbed periods or feed more at night (Owens 1977; Bélanger and Bédard 1990).

Environmental, physiological, biotic and abiotic factors may affect records of responses by waterfowl to disturbance (Bélanger and Bédard 1990). Many of these parameters (cloud cover, temperature, wind speed, wind direction, observer, sex, pair status, time of day and date) were measured and their effects on TA budgets were analyzed (see Chapter 2) but they were not incorporated into the analyses of effect of low-level aircraft on spring-staging waterfowl due to small sample sizes. Some of these parameters may influence apparent responses to aircraft noise (from Chapter 2: the amount of time Common Goldeneyes spent alert increased with increased wind speed). Further research with larger sample sizes to include all parameters in one analysis would be constructive.

Numbers of waterfowl are relatively low in this part of the Quebec-Labrador peninsula although the region is biologically productive overall, due to its vast area, sparse population and under-development. Historically Canada Goose and Black Duck populations have declined as a result of altered habitats and hunting pressure at the southern extent of their ranges therefore this region may become important to birds of Atlantic Flyway populations. Because effects of repeated disturbance from low-level jet aircraft may have a cumulative effect on waterfowl (Bélanger and Bédard 1990), such disturbances may contribute to future declines (Anonymous 1994). Alternatively, military over-flights have been occurring in the area since 1981, consequently birds may have habituated to flight occurrences (Stalmaster and Newman 1978).

Ashkui, the only areas of open water during the spring in this northern landscape, are important to Common Goldeneyes for foraging, and to Canada Geese and Black Ducks for resting prior to the breeding season.

Lac Fourmont and the connecting Little Mecatina River Valley is a target area for low-level training of military aircraft. This training overlaps spatially and temporally with spring-staging for these waterfowl. The occasional presence of low-level flying military jet aircraft (n=97) and predators such as bald eagle (*Haliaeetus leucocephalus*) and otter (*Lutra canadensis*) have resulted in short-term, behavioural changes of waterfowl (personal observation).

A study of bird collisions with civilian and military aircraft in the U.S.A. between 1990 and 1999 based on 20 893 bird strikes revealed that 15% of strikes occur between 1 and 99 feet above ground level and 16% occur between 100 and 499 feet (Anonymous 2001). Using criteria based on damage incurred and effect-on-flight, 21 species of wildlife were ranked as a relative risk hazard to aircraft (Dolbeer *et al.* 2000). As some of the world's largest flying birds, geese and ducks ranked third and seventh, respectively. Flocking and migratory behaviours make waterfowl particularly hazardous to aircraft operations (Anonymous 2001). Due to high numbers in Canada, strikes involving waterfowl are more common in this country, particularly during spring migration when waterfowl movement is at its highest (Blokpoel 1976). Because waterfowl numbers are relatively low at Lac Fourmont *ashkui*, flight closures may not be warranted.

RECOMMENDATIONS

This research has focused on immediate behavioural responses of waterfowl to noise and draws inference about time-activity budgets based on behavioural sampling. It is unknown what the site at Lac Fourmont *ashkui* offers in terms of food for these species. At this time of year there is virtually no exposed vegetation for geese to feed on. Prey sampling, nutrient value of foods, and a comprehensive understanding of energetic requirements of Canada Geese, Black Ducks and Common Goldeneyes on their staging grounds at Lac Fourmont *ashkui* in relation to aircraft disturbance is essential for optimum management. Further time-activity budgets would have been more representative or precise had we been able to measure nocturnal activity. Feeding by waterfowl species at night has been reported as a common occurrence in areas with heavy hunting pressure (Owen 1972; Owens 1977). Nocturnal studies at Lac Fourmont may have revealed a higher frequency of feeding at night but we did not measure this. Waterfowl vary their activity at night and in response to environmental stimuli (Paulus 1984; Jorde and Owen 1988). All studies of divers consider a dive as part of a feeding event whether the dive is successful or not. Site richness in prey may influence amount of time spent feeding. A duck foraging at a prey rich site may not need to spend as much time diving in search of food. Determining what Common Goldeneyes are preying upon is a next logical step for subsequent research. This combined with data collected over several years is required to determine population effects.

Supersonic military jet over-flight training has been proposed in the LLTA of the Quebec-Labrador Peninsula. Different types of aircraft have different noise signatures and it would be of value to conduct similar research to determine how supersonic over-flights affect waterfowl behaviour. Other research (Bélanger and Bédard 1989; Ward *et al.* 1999), has shown that military jet aircraft did have a disturbance effect on waterfowl. To better understand the nature of this effect, while maintaining the carrying capacity of this and similar staging habitats, it is suggested that further research should be conducted to determine if there are any biologically significant impacts on waterfowl as a result of low-level jet aircraft.

CONCLUSION AND MANAGEMENT IMPLICATIONS

Although this study found few negative impacts of low-level jet aircraft on waterfowl behaviour, further research is required to support the use of closures to keep staging waterfowl distant from low-level military activity during the period when waterfowl presence and military activity overlap spatially and temporally. Based on this data there is no evidence of any impact of military jets on Common Goldeneye, that is, no change in feeding (the most important behaviour for this species at this time) was detected. The relatively small numbers of waterfowl in this study area and lack of overt behavioural responses (i.e.

locomotion – flushing/flight) of spring-staging waterfowl can be seen to pose very little flight safety hazard to jet pilots.

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CONCLUDING TEXT

Until now little has been known about the spring-staging ecology of waterfowl within the boreal forest. We found that these spring-staging areas are important in terms of resting and sleeping for Canada Geese and Black Ducks and for feeding of Common Goldeneyes. Spring staging waterfowl and low-level military training overlap spatially and temporally in this northerly and remote boreal habitat. Statistically significant effects of low-level jet over-flights were detected with various measured parameters combined with certain behaviours for each of the three study species. Although, based on this data, military over-flights had no impact on Common Goldeneyes in that there was no change in their feeding behaviour, the dominant behaviour of this species. Waterfowl numbers are relatively low in this area, extra energetic expenditures by those birds affected may have negative biological impacts in terms of nutrient storage for egg-laying or other reproductive activity, for example. Further study is needed to verify if indeed these effects are biologically significant.

APPENDICES

Appendix A

Sunrise and sunset times for Lac Fourmont, Labrador during the 2002 field season (24 hour clock) (Environment Canada).

Date	Dawn	Dusk
April 24	0541	2017
April 25	0539	2019
April 26	0537	2021
April 27	0535	2023
April 28	0533	2024
April 29	0531	2026
April 30	0529	2028
May 1	0527	2029
May 2	0525	2031
May 3	0523	2033
May 4	0521	2034
May 5	0519	2036
May 6	0518	2038
May 7	0516	2039
May 8	0514	2041
May 9	0512	2043
May 10	0511	2044
May 11	0509	2046
May 12	0507	2048
May 13	0506	2049
May 14	0504	2051
May 15	0502	2052
May 16	0501	2054
May 17	0459	2055
May 18	0458	2057
May 19	0457	2058
May 20	0455	2100
May 21	0454	2101
May 22	0453	2103
May 23	0451	2104
May 24	0450	2106
May 25	0449	2107
May 26	0448	2108
May 27	0447	2110
May 28	0446	2111
May 29	0445	2112
May 30	0444	2113

Appendix B

Tally of all observation dates and time periods. Time periods 2 and 3 were 3 hours duration. Dawn and dusk sampling dates were chosen randomly and were 1.5 hours duration (1 = 1 active blind, 2 = 2 active blinds).

Date	Period 1	Period 2	Period 3	Period 4
26 April		2	2	
27 April		1	1	1
28 April		2	2	
29 April		2	2	
30 April		2	2	
1 May		2	2	
2 May		2	2	
3 May	2	2	2	
4 May	2	2	2	
5 May		2	2	2
6 May		2	2	2
7 May	1	2	2	
8 May		2	2	1
9 May		2	2	2
10 May		2	2	1
11 May	1	2	2	
13 May	2	2	2	
14 May		2	2	2
15 May		2	2	
16 May		2	2	1
17 May		2	2	
18 May		1	1	
19 May	2	2	2	
20 May		2	2	
21 May		2	2	2
22 May		2	2	
23 May		1	2	
24 May	1	2	2	
25 May		2	2	
27 May		1	2	

Appendix C

Behavioural categories and modifiers

Behaviour	Modifier
agonistic	
comfort	wingflap
	splashbathe
	preen
rest	
feed	surface
	dive
	pause
	peer
	upend
locomotor	scoot
	fly
	swim
	walk
stand	
out of sight	
courtship	within pair
	outside pair
	unknown pair status
alert	
sleep	

Appendix D

Waterfowl species present at Lac Fourmont during the spring 2002 field season

Canada Goose (*Brenta canadensis*)
American Black Duck (*Anas rubripes*)
Mallard (*Anas platyrhynchos*)
Northern Pintail (*Anas acuta*)
Green-winged Teal (*Anas crecca*)
Ring-necked Duck (*Aythya collaris*)
Greater Scaup (*Aythya marila*)
Surf Scoter (*Melanitta perspicillata*)
Black Scoter (*Melanitta nigra*)
Long-tailed Duck (*Clangula hyemalis*)
Common Goldeneye (*Bucephala clangula*)
Barrow's Goldeneye (*Bucephala islandica*)
Common Merganser (*Mergus merganser*)
Red-breasted Merganser (*Mergus serrator*)

Appendix E

Sample of Goose Bay daily flying forecast table (Hans Lindner, DND). First number indicates number of aircraft to have a sortie. Number in parenthesis indicates length of sortie in hours.

	Air Force and Aircraft Type			
Time (ZULU)	**German Air Force Transal**	**Royal Netherlands Air Force F16**	**German Air Force F4**	**Royal Air Force MRC**
1100				
1130				
1200				
1230		10 (1.0)		
1300			12 (1.2)	
1330				
1400				
1430				
1500				
1530		8 (1.0)		
1600				
1630				
1700	1 (2.5)		12 (1.2)	
1730				
1800				
1830		10 (1.6)		2 (1.5)
1900				
1930				
2000				
2030				
2100				
2130				
2200				
2230				2 (1.5)