Supporting Online Material for

Perceived Predation Risk Reduces the Number of Offspring Songbirds Produce per Year

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Movie S1

Materials and Methods

Study area and species

We studied wild, free-living, song sparrows (*Melospiza melodia*) at 11 locations distributed across five small (< 200 ha) Gulf Islands (Fig. S1), in B.C., Canada, from March to July 2010. The 11 locations all lie within a radius of 2.7 km centered at 48°44'15.93" N, 123°23'26.40" W. Over the past 10 years we have conducted a series of experimental and correlational studies concerning food and predator effects on the demography of the individually colour-banded birds resident at these locations. Details regarding locations and sparrows can be found elsewhere (*10, 11, 25, 26*). Briefly, sparrows in this area are resident year-round, pairs (female and male) occupy exclusive territories averaging 0.4 ha, they build open-cup nests typically in low shrubs (median nest height = 36 cm; details below) and build a new nest upon each attempt, egg-laying occurs from April to July, the maximum clutch size is 5 eggs, incubation lasts 13 days, mothers alone incubate the eggs whereas both parents feed the nestlings, nestlings normally fledge 12 days after hatching, all females normally produce at least two broods, and some females may fledge up to three broods per year.

Typically more than half of all offspring (eggs and nestlings) are directly killed by predators (*25*), in nests not experimentally protected from direct predation. Utilizing eight, custom-built, continuous video surveillance systems described below (Fig. S2), we collected video recordings of 225 nests and thus observed 115 predator attacks, involving raccoons (*Procyon lotor*), ravens (*Corvus corax*), crows (*Corvus caurinus*), brown-headed cowbirds (*Molothrus ater*) and owls (*11*). In some owl attacks the species involved was clearly the barred owl (*Strix varia*) but in others the species could not be identified. Cooper's hawks (*Accipiter cooperii*) are also present at our study locations and though we have yet to observe them attacking a nest, they have been recorded doing so elsewhere (*31*) and are known to represent a significant threat to adult sparrows (*32*).

Experimental design

Debate concerning the impacts of predators on wildlife populations has persisted in part because diagnosing the cause of death of wild animals is generally problematic, given the many logistical challenges involved (*1-3*). In our case we succeeded in being able to diagnose the cause of deaths as not being due to direct predation, by protecting every nest with both electric fencing (Fig. S3) and seine netting (Fig. S4), and verifying that there were no deaths due to direct predation using the continuous video surveillance systems noted above (Fig. S2; details below). By this means we were able to eliminate direct predation as a cause of any deaths, and were thus able to attribute any effect on survival solely to our manipulation of perceived predation risk. Throughout the main text and the Supporting Online Material we refer to the proportion of nestlings "expiring", or the proportion that "expired", because we know with certainty from our continuous video surveillance that no nestlings died a violent death. "Died" is non-specific with respect to cause of death whereas "expired" is more accurate in conveying that the cause was not a violent one.

Space presents one of the principal logistical challenges in attempting to manipulate perceived predation risk in free-living wildlife (*33*). Free-living animals can, and do, simply flee or avoid, a predator in a cage, predator models, or predator odour stations (*18*). Because sound effectively travels farther and so more fully occupies space,

than visual cues or odours, sound provides a more effective means of regularly exposing free-living wildlife to manipulated cues over an area the size of their entire territory, as opposed to just some small portion of it (*33*). Consequently, we chose to use playbacks of calls and sounds as the most effective means of manipulating perceived predation risk.

Though logistically very challenging the basic design of our experiment was very straightforward. We compared two groups, both exposed to playbacks with comparable acoustic properties broadcast under comparable conditions, which only differed with respect to whether the calls and sounds being broadcast were associated with either predators or non-predators. Our objective was to test whether perceived predation risk *per se* affected the number of offspring produced per year, and we thus used as large an array of predator calls and sounds as we could compose, given the set of predators in the area we knew attacked sparrows or their nests (see above; Table S1). To compose our playlist of non-predator calls and sounds (Table S1) we: i) excluded any associated with either obvious competitors (other songbirds), or potential food sources (invertebrates, e.g. crickets chirping); ii) included only calls and sounds known to be heard at our study locations; iii) matched our diurnal predator list with a diurnal non-predator list, and our nocturnal predator list with a nocturnal non-predator list; and then iv) matched each predator with a non-predator call or sound that had acoustic properties that were as similar as possible. Unlike our playlist of predator calls and sounds, derived from known attacks on nests (Table S1), there was no obvious commonality and no empirical reason to expect our playlist of non-predator calls and sounds signaled anything that might be expected to affect reproduction.

Eliminating direct predation

We actively eliminated direct predation by protecting every nest in the experiment with both electric fencing and seine netting as soon as it was found. Most nests were found early in incubation and there was no significant difference between the treatments in when nests were found (predator = 1.9 ± 0.4 day of incubation, non-predator = 2.9 ± 0.4, mean ± SE; $F_{1,22}$ = 3.08, P = 0.093). Electric fencing has previously been used to prevent raccoon predation on duck nests (*34*), and seine netting is commonly used to protect fishponds from attacks by predatory birds (*35*). Electric fences were constructed to completely encircle the nest at a radius of approximately 2 m with three strands of electrified wire located 8, 16, and 24 cm above the ground (Fig. S3), powered at 2 kV by a portable fence charger (Deter 200; Hallman Fence Systems Inc., Winnipeg, MN). The seine netting (Muketsu 210/52 x 3-5/8" x 100 MD; Pacific Net and Twine Ltd., Vancouver, BC) was typically draped over tepees constructed above the nest that we made from available deadfall (Fig. S4). Pilot studies indicated that the mesh size utilized provided ready access by sparrows while preventing access by larger birds. To additionally ensure that we eliminated predation or parasitism by brown-headed cowbirds, we erected cowbird traps (*36*) across our study locations before the breeding season began, and removed all cowbirds caught, throughout the season (*11*).

We were able to establish the fate of every egg and nestling with certainty utilizing eight, custom-built, continuous video surveillance systems (Fig. S2). Each system can continuously record the activity at up to eight nests at a time using miniature (3.7 cm diameter x 8.6 cm length), colour/infrared cameras, any of which may be located up to 300 m from the digital recording device. The cameras' infrared emitters permit recording day and night. Being solar-powered there was no restriction on where systems

could be located. Cameras were attached to stakes positioned 25 cm from the edge of the nest. Nests were monitored over the complete nesting cycle. Times when there was no activity at the nest were automatically edited-out from the recordings utilizing the digital recording device's motion detection function. In addition to verifying that there was no direct predation, we used these recordings to assess the effects of our treatments on nest attendance during incubation (Fig. 4C) and parental feeding rates during brood-rearing (Fig. 4D; details below).

Implementing the playbacks

As already noted, our objective was to test whether perceived predation risk *per se* affected offspring production. Some predators no doubt represent more of a threat than others, and more of a threat to offspring than parents, and it will be fruitful to evaluate the effects of cues from specific predators in future studies. In addition to predator vocalizations we included sounds predators may make when hunting (Table S1, brush disturbance sound, owl wing-beat sound), because it has recently been experimentally demonstrated that the sound of a predator walking on leaf litter can cause nestling birds to respond by begging less or not at all (*37, 38*), and such sounds may presumably also alarm their parents.

We matched the acoustic properties of the predator and non-predator playlists (Table S1) by pairing each predator call or sound with a non-predator call or sound that qualitatively sounded as similar as possible, shared similar frequency characteristics (Table S2), and had a similar temporal structure judged by visually comparing their spectrograms and waveforms (*39*). We statistically verified that there were no significant differences in the overall frequency characteristics between the two playlists by conducting, paired *t*-tests of each of four frequency characteristics (Table S2; peak $t_{1,11} = 0.99$, $P = 0.344$; maximum $t_{1,11} = 0.54$, $P = 0.600$; minimum $t_{1,11} = 0.68$, $P = 0.511$; range $t_{1,11} = 0.45$, $P = 0.663$), and a discriminant function analysis of all four taken together (DFA eigen-value = 0.11, Wilks' $\lambda = 0.90$, $P = 0.717$). We used at least two different recordings of every call and sound, obtained from at least two sound archives, and there was no significant treatment difference in the mean number of recordings per call or sound (predator = 7.1 ± 1.2, non-predator = 6.6 ± 1.2, mean ± SE; $F_{1,22} = 0.08$, $P = 0.777$). We edited and standardized the volume at which all calls and sounds were to be broadcast (90 dB at 1 m) using Raven Lite 1.0 (*40*).

Playbacks were broadcast under uniform conditions. Playbacks were all broadcast using identical speakers, housed in weatherproof boxes that also housed an mp3 player (all identical) and batteries sufficient to power the player and speakers for 2 weeks. We balanced the distribution of playbacks across islands as much as possible (Fig. S1) and included study location as a random effect in all analyses (details below). Broadcasting began at all study locations on 15 March, before the first eggs of the season were laid (Fig. 2), and continued until 24 July. Speakers were distributed every 0.4 ha (roughly one per territory) at each study location. The speakers were hung from trees at about chest height (1.3 m), and on every eighth day were moved to different trees and oriented in different directions, to avoid habituation (details below). The volume at which the speakers were broadcasting (90 dB at 1 m) was checked every time they were repositioned, using a sound pressure level meter. Playbacks were broadcast 24 hr/day. Appropriate diurnal and nocturnal calls and sounds were broadcast at appropriate times of the day (e.g. diurnal predator calls were only broadcast during the daytime; Table S1),

and we altered the ratio of diurnal and nocturnal calls and sounds accordingly as the nights became shorter and longer again, over the season.

Because speakers were deployed before the first nests of the season were built (Fig. 2) and we could not control where the sparrows positioned their nests, we statistically verified that there were no significant treatment differences in either the minimum (predator = 50.0 ± 5.8 m, non-predator = 39.2 ± 4.7, mean ± SE; $F_{1,22}$ = 1.17, P = 0.290) or mean (predator = 51.7 ± 5.9 m, non-predator = 51.9 ± 6.1, mean ± SE; $F_{1,22}$ < 0.01, P = 0.991) distance between speakers and nests. We verified that there was no significant treatment difference in the incidence of naturally-occurring predator calls and sounds (predator = 0.25 ± 0.05 average detections per study location, non-predator = 0.17 ± 0.04, mean ± SE; $F_{1,9}$ = 1.30, P = 0.284) by walking fixed 100 m transects and recording every predator call or sound heard, every eighth day, at each study location. Transects were conducted prior to repositioning the speakers, after they had been turned off for four days (details below). Finally, we also verified that there was no significant treatment difference between the study locations in nest predation rates in previous years (χ^2_1 = 0.28, P = 0.600; analyzed using program CONTRAST; *41*), based on data from a previous study (*25*).

Habituation presents a further logistical challenge in attempting to manipulate perceived predation risk, particularly when trying to do so throughout an entire breeding season. Using multiple recordings of multiple calls and sounds (Table S1) assisted with ameliorating habituation. In addition, we scrambled the order in which calls and sounds were broadcast, interspersed periods of silence among the calls and sounds both within and between days, and repositioned and reoriented the speakers every eighth day as already noted. Within a 24 hr period, broadcasts of calls and sounds (average duration 2 min. and 20 sec.) were interspersed with periods of silence (*42, 43*), in a ratio of 1:1.5 (broadcast : silence) during the day and 1:2.3 during the night, the different diurnal and nocturnal ratios reflecting the different number of diurnal (more) and nocturnal (fewer) calls and sounds in the playlists (Table S1). A period of 96 hours of silence ought to largely eliminate habituation (*44*), so we interspersed 4 days of silence between every four days of broadcasting (i.e. calls and sounds were broadcast on a 4-day-on-4 day-off cycle). We conducted our survey of naturally-occurring predator calls and sounds, described above, at the end of every 4-day-off period.

General field procedures

Territories were censused beginning on 1 March. Nests were located using behavioural cues from the mother (*26*). Eggs were weighed to 0.01 g using an electronic balance. Nestlings were weighed to 0.01 g using an electronic balance, and individually colour-banded, on day 6 of brood-rearing (*25*). We are confident we found every nest begun by every experimental subject because there were no inter-nest intervals long enough to suggest we missed a nest (*11*).

Measurement of effects on offspring condition and parental behaviour

We measured the effect of perceived predation risk on egg mass (Fig. 3A) because as noted in the main text, an effect on egg mass was found in one of the two previous experiments to have tested the effect of perceived predation risk on the annual number of propagules produced in free-living wildlife (*7*). We also expected that perceived predation risk may impair foraging and so have effects resembling limitation by food supply (*1-5, 7-11, 25, 26, 30, 45*) and we previously experimentally demonstrated that

food supply affects both egg number and mass (*26, 29*). There was no significant treatment difference in the age at which eggs were weighed (predator = 5.8 ± 0.6 day of incubation, non-predator = 5.6 ± 0.7, mean ± SE; $F_{1,22}$ = 0.06, P = 0.808) and the analysis reported (Fig. 3A) concerns initial egg mass, calculated following the standard procedure validated for song sparrows (*46*) of correcting for the estimated 15 % decrease in egg mass over the incubation period (*47*).

Anticipating that foraging may be impaired (*1-5, 7-11, 25, 26, 30, 45*) we additionally quantified the effect of perceived predation risk on both brood mass (Fig. 3B) and parental provisioning (feeding visits per hour; details below). Brood mass may be viewed as reflecting the cumulative effect of parental provisioning (*16*). We report the effect of perceived predation risk on brood mass, rather than nestling mass, because an effect on brood mass better conveys the idea of an effect on the cumulative or total amount of biomass brought to the nest by the parent (i.e. parental effort; *16*), whereas nestling mass may be additionally influenced by how that biomass is divvied-up amongst the nestlings (*29*). This is simply a question of presentation since there was a significant treatment effect whether we analyzed either brood or nestling mass (details below).

We measured the effect of perceived predation risk on nestling skin temperature 10 min. after the mother flushed from the nest (Fig. 3C) to determine if exposure may have been a contributing proximate cause of nestling deaths. Regardless of age, nestling skin temperature may be expected to be close to that of the mother's body temperature at the moment at which she flushes from the nest (*17*). We anticipated that nestlings that were more vulnerable to thermoregulatory stress (those with a lower skin temperature 10 min. after the mother flushed; *17*) would be more likely to die of exposure (Table S4). As noted above, no nestling died a violent death, nor did they appear to be diseased. Consequently, exposure or starvation remain as the most probable proximate causes. The symptoms displayed by nestlings that expired also appear consistent with either of these two causes. Based on the videos from this study and previous recordings of an additional 225 nests, nestlings that expired, progressively begged less, appeared increasingly lethargic and eventually simply stopped moving altogether. We measured the skin temperature of every nestling in the brood on day 2 of the brood-rearing period (*17*) using a digital thermometer and probe (IRT thermometer and 307-159 Fast Response probe; ThermoWorks Inc., Lindon, UT). The probe was pressed against the ventral surface or side of each nestling, beneath the wing and above the lung (*17*). We report the effect on the mean skin temperature of all the nestlings in the brood (Fig. 3C).

Perceived predation risk could affect the frequency of nestling deaths due to exposure through effects on nestling body size or physiology or the microclimate nestlings are exposed to, or any combination of such effects. Smaller nestlings are more vulnerable to thermoregulatory stress (*17, 48*) so effects on egg or brood mass, as discussed above, could affect this. Thermoregulatory ability even in nestlings as young as 2 days of age is a function of metabolic processes, some of which are independent of body size (e.g. *49*), so effects on the physiology of nestlings, potentially resulting from effects of perceived predation risk on egg quality, could also contribute to vulnerability to thermoregulatory stress. Perceived predation risk could additionally cause nestlings to be exposed to a colder microclimate, due to parents selecting to build their nests in more concealed sites (Fig. 4A; *4, 6*). A colder microclimate might increase the frequency of

nestling deaths, either by itself, or by exacerbating the circumstances of nestlings already more vulnerable to thermoregulatory stress as a result of some other cause (Table S4). Exposure to a colder microclimate might additionally affect the proportion of eggs that hatch (Table S4). We decided against measuring nest temperature during the egg stage because we knew from previously having done so (20) that this entails some risk of causing nest abandonment, which we could not afford to have happen in this experiment.

Several recent experiments have demonstrated that perceived predation risk may affect nest site selection (4, 6, 42). To evaluate the effects of perceived predation risk on nest site selection (Fig. 4A) we quantified the density and thorniness of the vegetation surrounding the nest (Fig. S5A), and the position of the nest within the plant in which it was located (Fig. S5B). To quantify density and thorniness we counted the number of times vegetation contacted a 1 m ruler held horizontally or vertically in a given proximity to the nest (50-52). Density refers to the total number of contacts (50) and thorniness refers to the total number that involved thorny vegetation (typically rose [*Rosa sp.*] or blackberry [*Rubus sp.*]). The ruler was held (Fig. S5A): perpendicularly above the nest; horizontally, at nest height, in contact with the edge of the nest, in each of the four cardinal directions; and vertically, touching the ground, at three distances from the edge of the nest (10 cm, 50 cm and 1 m), in each of the four cardinal directions. To quantify the position of the nest we measured (Fig. S5B): the height of the nest above ground (42, 51-54); the height of the plant in which it was located (51, 53, 54), and the shortest distance from the edge of the nest to the edge of the plant it was located in (50, 54, 55). All measurements were made after the nest was no longer in use. For scale (Fig. S5), virtually all nests were < 1 m above ground (median height = 36 cm; 2.5 - 97.5[th] percentiles = 0.0 - 93.5 cm).

Flight initiation distance (FID), defined as the distance at which an animal begins to flee from an approaching experimenter or predator, has been used to quantify skittishness (or "fear"; 18) in virtually every major vertebrate taxa (18). In birds, FID has been repeatedly used to assess whether tourist disturbance is responsible for adversely affecting hatching success or nestling survival (e.g. 56, 57). We thus expected that perceived predation risk would affect flight initiation distance (Fig. 4B), and flight initiation distance would be associated with either or both, poorer hatching success or decreased nestling survival (Table S4). We measured flight initiation distance on day 2 of the brood-rearing period by having the same observer every time (MCA) walk steadily towards the nest at the same pace and mark their location when they saw the mother flush from the nest.

We measured the effect of perceived predation risk on nest attendance during incubation (Fig. 4C) because nest attendance was shown to be affected in the sole previous experiment (4, 8) to have evaluated the effect of perceived predation risk on incubation behaviour (7). In this previous study, nest attendance was quantified by calculating the ratio: (mean on-bout duration / [mean on-bout duration + mean off-bout duration]) (19). It also seemed possible that incubation behaviour may be affected in a fashion comparable to that resulting from limitation by food supply given that perceived predation risk may be expected to impair foraging (1-5, 7-11, 25, 26, 30, 45), and experimental work has shown that food supply may affect nest attendance (20). We evaluated the effect of perceived predation risk on nest attendance by quantifying the duration of both on- and off-bouts (19, 20), on the 12th day of incubation, recorded using

our continuous video surveillance systems (Fig. S2). The repeated-measures analysis of the duration of on- and off-bouts that we report (Fig. 4C; details below) is an alternative means of quantifying nest attendance that is directly comparable to the method of calculating the ratio of the duration of on- and off-bouts. There was a significant treatment effect on nest attendance whether tested using the repeated-measures approach (Fig. 4C) or the ratio method ($F_{1,22} = 5.75$, $P = 0.025$).   We previously showed that females that spend shorter times on and longer times off the nest during incubation, as predator playback females did (Fig. 4C), are more likely to lose their entire clutch (*20*). Variation in the proportion of the clutch that hatches may also be expected to vary with the mean duration of incubation on- and off-bouts (Table S4), if this compromises the temperature regulation of the eggs (*4, 6*).

A number of recent experiments, utilizing predator playbacks (*22*), predator models (*21, 42, 58, 59*) and predator removal (*7*), have demonstrated that perceived predation risk can cause a reduction in the rate of parental feeding visits during brood-rearing (Fig. 4D). Though it is asserted (*4, 22, 59*) or assumed (*7, 42, 58*) that this will adversely affect nestling mass and survival, none of the experiments cited have evaluated whether the observed reduction in feeding visits is associated with resulting reductions in mass or survival (Table S4). We evaluated the effect of perceived predation risk on parental feeding visits by quantifying the number of visits made per hour on day 5 of brood-rearing, recorded using our continuous video surveillance systems (Fig. S2). As previously noted, the brood was weighed on day 6. Quantifying parental feeding visits on day 5 thus permitted us to relate this to brood mass the next day (Table S4), while avoiding the interruption of parental feeding visits caused by our visiting the nest to weigh the brood.

Statistical analyses

In line with our experimental design being very straightforward our analyses were for the most part also very straightforward. Treatment effects reported in Figs. 1, 3 and 4 are all per female, consistent with the standard demographic view of populations (*60*). Totals in Fig. 1 refer to the total per female summed across all her nests (e.g. Fig. 1A, total number of offspring produced *per female* per year), and means in Figs. 3 and 4 refer to the mean per female averaged across all her nests (e.g. Fig. 3A, mean of the mean egg mass in each of her clutches). In all tests of treatment effects we used mixed model ANOVAs which included study location as a random effect, though there was no substantive difference in the results whether or not this term was included. Results regarding treatment effects reported in the main text are from one-way ANOVAs with the exception of the analyses of treatment effects on brood mass (details below), nest site selection (details below), and nest attendance during incubation. The latter was analyzed using a one-way, repeated-measures ANOVA, with the repeated measure being the mean duration of each female's on- and off-bouts (Fig. 4C). We found no substantive difference in the results regarding treatment effects on offspring condition (Fig. 3) and parental behaviour (Fig. 4) whether we used the mean per female, or utilized the data from all nests and included female identity as a random effect.

We anticipated that brood mass (Fig. 3B) would vary with brood size and brood mass was highly correlated with brood size (Pearson correlation coefficient = 0.86, $P < 0.001$). Recent research has shown that nestling growth rates may vary linearly or quadratically with brood size, indicating that brood and nestling mass may be expected to

as well (*16*). To account for the variation in brood mass due simply to differences in brood size we tested for a treatment effect on brood mass by conducting an ANCOVA with brood size included as both a linear and quadratic covariate (brood size $F_{1,22} = 16.08$, $P < 0.001$; brood size^2 $F_{1,22} = 4.65$, $P = 0.042$). We report the significant main effect from this analysis (Fig. 3B) in the main text. As discussed above, whether we report this as an effect on brood mass or nestling mass is simply a question of presentation. The main effect was comparable ($F_{1,22} = 4.98$, $P = 0.036$) if we conducted an ANCOVA on mean nestling mass with brood size again included as both a linear and quadratic covariate (brood size $F_{1,22} = 4.66$, $P = 0.042$; brood size^2 $F_{1,22} = 5.52$, $P = 0.028$). To evaluate the associations between brood mass corrected for brood size and other variables reported in Tables S4 and S5 we used the residuals from the linear and quadratic regression of brood mass against brood size. There was no difference in the nature of any of the associations if the residuals from just the linear regression were used instead.

   To evaluate whether nest site selection differed between the treatments (Fig. 4A) we conducted a discriminant function analysis (DFA) of the measures illustrated in Fig. S5 (*50, 53, 61, 62*). We eliminated redundant measures by excluding any that were highly correlated (correlation coefficient > 0.70) with another measure that demonstrated a greater univariate difference between the treatments (established using *t*-tests), and then further reduced the number of measures sufficient to significantly discriminate between the treatments by conducting a forward stepwise DFA (*50, 53, 61, 62*). The final analysis established that just two measures were sufficient to significantly discriminate between the treatments, the density and the thorniness of the vegetation surrounding the nest, measured horizontally from the edge of the nest (Fig. S5A). We subsequently conducted two further analyses to ensure our results were conservative. First, we verified the model's significance by conducting a permutation test of the DFA's eigen-value (*11, 63*). Next, we conducted a one-way ANOVA of the canonical scores from the final DFA that included study location as a random effect. Fig. 4A illustrates the result from this ANOVA and the *P*-value reported comes from this (most conservative) analysis.

   Our primary objective was to experimentally test whether perceived predation risk could alone affect the number of offspring produced per year (Fig. 1A), and so be powerful enough to affect population dynamics. Our objective in additionally testing for treatment effects on the number of eggs laid (Fig. 1B), hatching success (Fig. 1C), nestling survival (Fig. 1D), offspring condition (Fig. 3) and parental behaviour (Fig. 4), was to begin to elucidate all of the steps in the pathway from: the prey's perception of predation risk, to its anti-predator responses, to any resulting changes in demography (*1-3*). Physiological responses may also be involved (*10, 11, 64*), along with other behavioural responses. To identify whether effects on the behavioural responses measured in this study were associated with effects on offspring condition and survival, we examined the correlations between each of our four behavioural measures and the changes in offspring condition or survival (Table S4). Because our purpose was simply to identify associations we utilized all the available data from every nest in evaluating each association, based on its Spearman's rank correlation coefficient.

   Prior to parametric analyses all data were tested for normality and homogeneity of variances. In the main text we report only values for those statistical terms that were significant and meaningful.
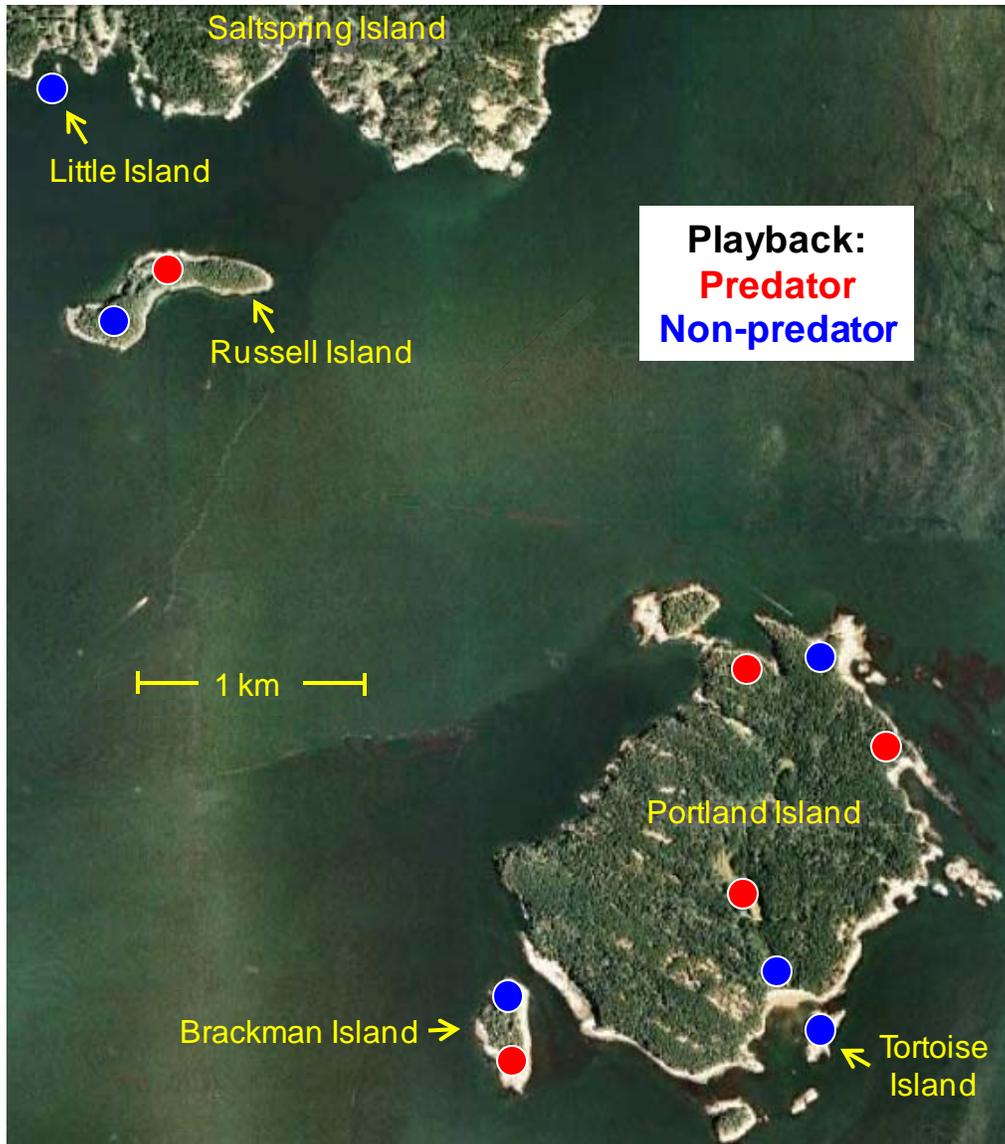
Fig. S1. Distribution of the predator (red) and non-predator (blue) playback locations on the several small Gulf Islands, in B.C., Canada, where the experiment was conducted.

Fig. S2. Schematic illustration of one of the custom-built, solar-powered, continuous video surveillance systems used to monitor nests. Each system can record the activity at up to eight nests at a time using miniature, colour/infrared cameras, any of which may be located up to 300 m from the digital recording device (grey unit in green box).

Fig. S3. Illustration of an electric fence (orange wire) encircling a sparrow nest location.
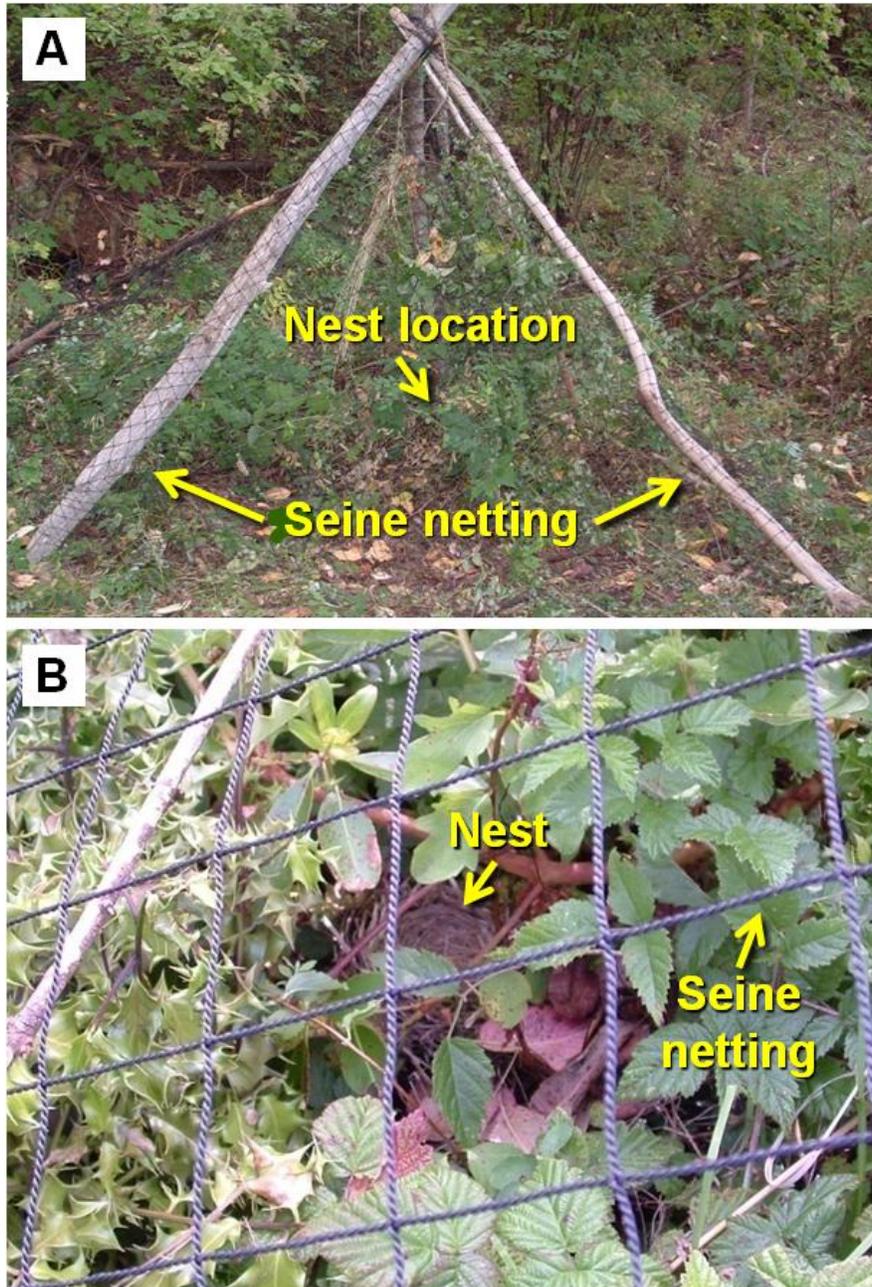
Fig. S4. Illustration of the use of seine netting to protect sparrow nests. (**A**) the seine netting was typically draped over tepees, constructed above the nest's location, that were made from available deadfall, (**B**) the mesh size of the netting permitting sparrows ready access to their nests while preventing access by larger birds.

A

Density and thorniness quantified by counting number of times
vegetation contacted a 1 m ruler:

Above nest

Vertical

Horizontal

10 cm   ground level

50 cm

1 m

B

Height
of plant
in which
nest was
located

Height
of nest
above
ground

Shortest distance   ground level
from edge of nest
to edge of plant
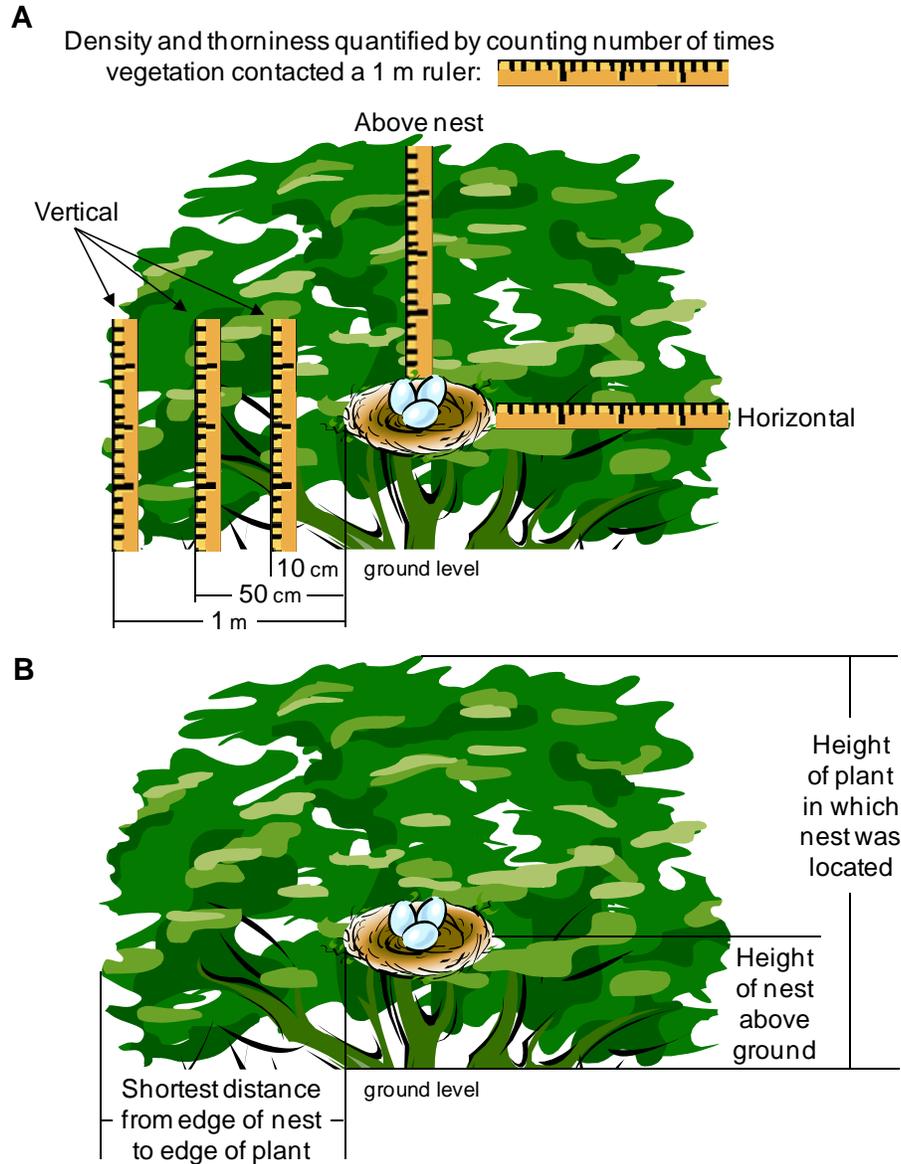
Fig. S5. Schematic illustration of the measures used to evaluate the effects of perceived predation risk on nest site selection. (**A**) the density and thorniness of the vegetation surrounding the nest was quantified by counting the number of times vegetation contacted a 1 m ruler held in proximity to the nest in the illustrated positions, (**B**) the position of the nest within the plant in which it was located being quantified using the three measures illustrated. For scale, almost every nest was < 1 m above ground (median height = 36 cm).

Table S1. Playlists of the calls and sounds used in the predator and non-predator playback treatments. All calls and sounds were known to be heard at our study locations. Each predator call or sound was matched with a non-predator call or sound that was, appropriate for the same time period (i.e. day vs. night), and had acoustic properties that were as similar as possible.

Time when broadcast	Matched calls and sounds	
	Predator treatment	Non-predator treatment
Day	Common raven (*Corvus corax*)	Canada goose (*Branta canadensis*)
Day	Northwestern crow (*Corvus caurinus*)	Mallard duck (*Anas platyrhynchos*)
Day	Cooper's hawk (*Accipiter cooperii*)	Northern flicker (*Colaptes auratus*)
Day	Brown-headed cowbird male song (*Molothrus ater*)	Rufous hummingbird (*Selasphorus rufus*)
Day	Brown-headed cowbird female chatter (*Molothrus ater*)	Belted kingfisher (*Ceryle alcyon*)
Day	Raccoon – social (purring) (*Procyon lotor*)	Downy woodpecker (*Picoides pubescens*)
Day + Night	Raccoon – aggressive (*Procyon lotor*)	Harbour seal (*Phoca vitulina*)
Day + Night	Brush disturbance sound (*Not species-specific*)	Surf sound
Night	Western screech-owl (*Otus kennicotti*)	Common loon (*Gavia immer*)
Night	Northern saw-whet owl (*Aegolius arcadius*)	Pacific chorus frog (*Pseudacris regilla*)
Night	Barred owl (*Strix varia*)	Wood frog (*Rana sylvatica*)
Night	Owl wing-beat sound (*Not species-specific*)	Wind sound

Table S2. Frequency characteristics of the matched predator and non-predator calls and sounds.

Treatment	Matched calls and sounds	Frequency characteristics (Hz)			
		Peak	Maximum	Minimum	Range
Predator	Common raven	1500	4000	400	3600
Non-predator	Canada goose	1000	5800	200	5600
Predator	Northwestern crow	1500	7500	500	7000
Non-predator	Mallard duck	1900	3500	500	3000
Predator	Cooper's hawk	2300	8400	250	8150
Non-predator	Northern flicker	2700	8700	1000	7700
Predator	Cowbird male song	6400	12000	1700	10300
Non-predator	Rufous hummingbird	6000	8300	100	8200
Predator	Cowbird female chatter	4700	14000	1400	12600
Non-predator	Belted kingfisher	4000	12000	600	11400
Predator	Raccoon – social (purring)	1000	6500	1200	5300
Non-predator	Downy woodpecker	720	10000	1000	9000
Predator	Raccoon – aggressive	1800	6000	250	8050
Non-predator	Harbour seal	800	5100	750	4350
Predator	Brush disturbance sound	400	7000	450	6550
Non-predator	Surf sound	360	15000	100	14900
Predator	Western screech-owl	700	2000	250	1750
Non-predator	Common loon	850	3700	300	3400
Predator	Northern saw-whet owl	1200	4000	400	3600
Non-predator	Pacific chorus frog	1500	4300	700	3600
Predator	Barred owl	1300	3500	100	3400
Non-predator	Wood frog	1400	5200	300	4900
Predator	Owl wing-beat sound	220	1700	100	1600
Non-predator	Wind sound	250	1100	0	1100

Table S3. Treatment effects on the mean number of eggs, hatchlings and fledglings in the first and second nests of the season, as illustrated in Fig. 2, and treatment by nest interaction effects concerning the number of eggs laid, the proportion that failed to hatch, and the proportion of nestlings that expired prior to fledging. Numbers in bold signify significant effects, indicated by asterisks in Fig. 2. The interaction terms reported are from repeated-measures analyses.

Nest or interaction	Number per nest	$F_{1,22}$	P
First nest	Eggs	**4.66**	**0.042**
	Hatchlings	**5.01**	**0.036**
	Fledglings	**4.86**	**0.038**
Second nest	Eggs	0.46	0.504
	Hatchlings	1.74	0.200
	Fledglings	**11.32**	**0.003**
Treatment by nest interaction	Eggs laid	0.50	0.488
	Proportion of eggs that failed to hatch	0.21	0.866
	Proportion of nestlings that expired	0.45	0.508

Table S4. Associations between the four measures of parental behaviour quantified, and offspring (egg or nestling) condition and survival. Each association was evaluated using Spearman's rank correlation coefficient and all the available data from every nest. Numbers in bold indicate significant associations.

Parental behaviour or offspring condition	Measure of offspring condition or survival	Correlation	*P*
Nestling skin temp. 10 min. after mother flushed	Proportion of nestlings that expired prior to fledging	**-0.37**	**0.011**
Density and thorniness of vegetation surrounding nest (nest site selection)	Proportion of eggs that failed to hatch	0.05	0.719
	Proportion of nestlings that expired prior to fledging	**0.32**	**0.031**
Flight initiation distance	Proportion of eggs that failed to hatch	**0.30**	**0.036**
	Proportion of nestlings that expired prior to fledging	0.10	0.519
Nest attendance during incubation	Proportion of eggs that failed to hatch [1]	-0.13	0.369
Feeding visits per hour during brood-rearing	Brood mass corrected for brood size	**0.30**	**0.037**
	Proportion of nestlings that expired prior to fledging	**-0.31**	**0.034**
Brood mass corrected for brood size	Proportion of nestlings that expired prior to fledging	**-0.31**	**0.033**

[1] We previously showed that females that spend shorter times on and longer times off the nest during incubation, just as predator playback females did (Fig. 4C), are more likely to lose their entire clutch (*20*), whereas the result here concerns only the loss of some portion of the clutch.

Table S5. Associations between nestling thermoregulatory stress (nestling skin temp. 10 min. after mother flushed from nest) and brood mass, and the proportion of nestlings that expired at different times during the brood-rearing period. At hatch, nestlings are naked and essentially ectothermic. By day 6 post-hatch, when brood mass was measured, they are feathered and almost wholly able to regulate their own temperature, which they can do so completely by day 8 (*17, 48*). Each association was evaluated using Spearman's rank correlation coefficient and all the available data from every nest. Numbers in bold indicate significant associations.

Measure of offspring condition	Proportion of nestlings that expired prior to fledging	Correlation	*P*
Nestling skin temp. 10 min. after mother flushed	Before day 6 post-hatch	**-0.32**	**0.025**
	After day 6 post-hatch	-0.18	0.211
Brood mass corrected for brood size	Before day 6 post-hatch	-0.15	0.319
	After day 6 post-hatch	**-0.36**	**0.012**

Table S6. All data necessary for a reader of *Science* to understand and evaluate the conclusions of the paper. Values are the total or average per territorial female compared between females exposed to predator (P) or non-predator (NP) playbacks throughout the breeding season. Order within treatments may vary among independent variables.

| | Figure 1 | | | | Figure 2 | | | | | | Figure 3 | | | Figure 4 | | | |
| | 1A | 1B | 1C | 1D | Nest 1 | | | Nest 2 | | | 3A | 3B | 3C | 4A | 4B | 4C | 4D |
Treatment	Total number of offspring produced per year	Total number of eggs laid	Total proportion of eggs that failed to hatch	Total proportion of nestlings that expired	Eggs	Hatchlings	Fledglings	Eggs	Hatchlings	Fledglings	Egg mass (g)	Brood mass (g) corrected for brood size	Nestling skin temperature (C) 10 min. after mother flushed	Density and thorniness of vegetation around nest (DFA canonical scores)	Flight initiation distance (cm)	Incubation on bout (min.)	Incubation off bout (min.)	Feeding visits per hour
P	2	7	0.286	0.600	3	2	2	3	3	2	2.95	47.84	20.23	0.030	199	13.19	5.8	7.00
P	4	6	0.200	0.000	3	3	2	3	2	2	2.76	35.91	27.20	0.150	97	13.74	6.32	4.95
P	3	7	0.286	0.400	3	2	2	4	3	1	2.76	42.07	21.53	-0.615	160	16.63	6.8	8.47
P	6	8	0.000	0.250	3	3	3	3	2	2	2.67	40.20	21.48	0.410	240	16.77	7.22	10.78
P	5	6	0.167	0.000	3	3	3	3	3	0	3.04	34.83	23.97	-0.135	307	17.86	8.82	6.00
P	4	6	0.167	0.200	3	3	2	3	2	2	3.27	42.55	24.89	-0.020	215	17.05	7.73	10.71
P	1	7	0.143	0.833	3	3	3	4	4	2	3.44	38.77	21.59	0.210	400	12.29	8.77	15.09
P	4	6	0.167	0.200	4	2	2	2	2	2	3.05	30.52	24.19	0.600	380	21.02	8.11	4.79
P	3	6	0.000	0.500	4	4	0	3	2	1	2.99	30.07	25.39	1.855	158	21.9	8.79	6.46
P	4	6	0.167	0.200	4	2	0	3	3	2	3.56	41.54	22.37	1.165	163	18.86	11.39	5.60
P	4	6	0.167	0.200	3	3	3	3	2	1	3.23	49.58	26.43	1.085	216	11.38	8.54	8.74
P	5	7	0.000	0.286	4	4	4	4	4	2	2.66	23.62	22.67	1.285	300	19.21	10.95	9.30

Table is continued on next page

Table S6 – continued. All data necessary for a reader of *Science* to understand and evaluate the conclusions of the paper. Values are the total or average per territorial female compared between females exposed to predator (P) or non-predator (NP) playbacks throughout the breeding season. Order within treatments may vary among independent variables.

| | Figure 1 | | | | Figure 2 | | | | | | Figure 3 | | | Figure 4 | | | |
| | 1A | 1B | 1C | 1D | Nest 1 | | | Nest 2 | | | 3A | 3B | 3C | 4A | 4B | 4C | 4D |
Treatment	Total number of offspring produced per year	Total number of eggs laid	Total proportion of eggs that failed to hatch	Total proportion of nestlings that expired	Eggs	Hatchlings	Fledglings	Eggs	Hatchlings	Fledglings	Egg mass (g)	Brood mass (g) corrected for brood size	Nestling skin temperature (C) 10 min. after mother flushed	Density and thorniness of vegetation around nest (DFA canonical scores)	Flight initiation distance (cm)	Incubation on bout (min.)	Incubation off bout (min.)	Feeding visits per hour
NP	6	7	0.000	0.143	4	4	3	3	3	2	2.72	46.87	28.15	-1.985	70	17.67	8.09	11.49
NP	6	6	0.000	0.000	4	4	3	3	3	2	3.06	55.42	18.35	0.835	77	23.32	6.62	11.16
NP	5	6	0.000	0.250	4	4	4	3	2	2	2.83	40.89	29.60	-1.555	70	14.07	7.24	10.58
NP	7	8	0.000	0.125	4	2	2	2	2	1	2.51	57.86	30.78	-1.040	100	19.17	7.97	8.21
NP	6	7	0.000	0.143	4	4	3	3	3	3	2.66	29.86	24.91	-0.460	100	22.91	8.21	14.01
NP	5	7	0.286	0.000	4	4	4	4	4	3	3.16	42.62	25.42	-0.975	121	18.42	8.36	9.74
NP	5	7	0.000	0.286	4	4	4	4	4	4	2.99	45.20	30.19	0.890	100	19.55	8.13	11.65
NP	5	7	0.143	0.167	4	4	4	4	4	3	2.71	46.55	30.62	-0.520	410	14.57	5.71	14.31
NP	8	8	0.000	0.125	3	3	3	3	3	3	2.81	40.95	29.45	-1.625	98	18.21	8.63	10.30
NP	5	7	0.000	0.286	3	3	2	4	4	4	2.45	45.13	24.75	0.055	113	18.9	7.43	7.79
NP	6	7	0.143	0.000	4	4	3	3	2	2	2.89	36.97	21.68	-0.600	105	17.05	7.16	9.39
NP	8	8	0.000	0.000	3	2	2	4	3	3	2.46	57.03	30.17	0.970	55	18.4	7.28	8.91

Movie S1. Video narrated by lead author Liana Zanette describing how the researchers eliminated direct predation and manipulated perceived predation risk, and discussing some implications for conservation and wildlife management.

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