Light pollution increases neurogenesis and suppresses melatonin in birds in a dose-dependent manner

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האגודה הישראלית לתאורה

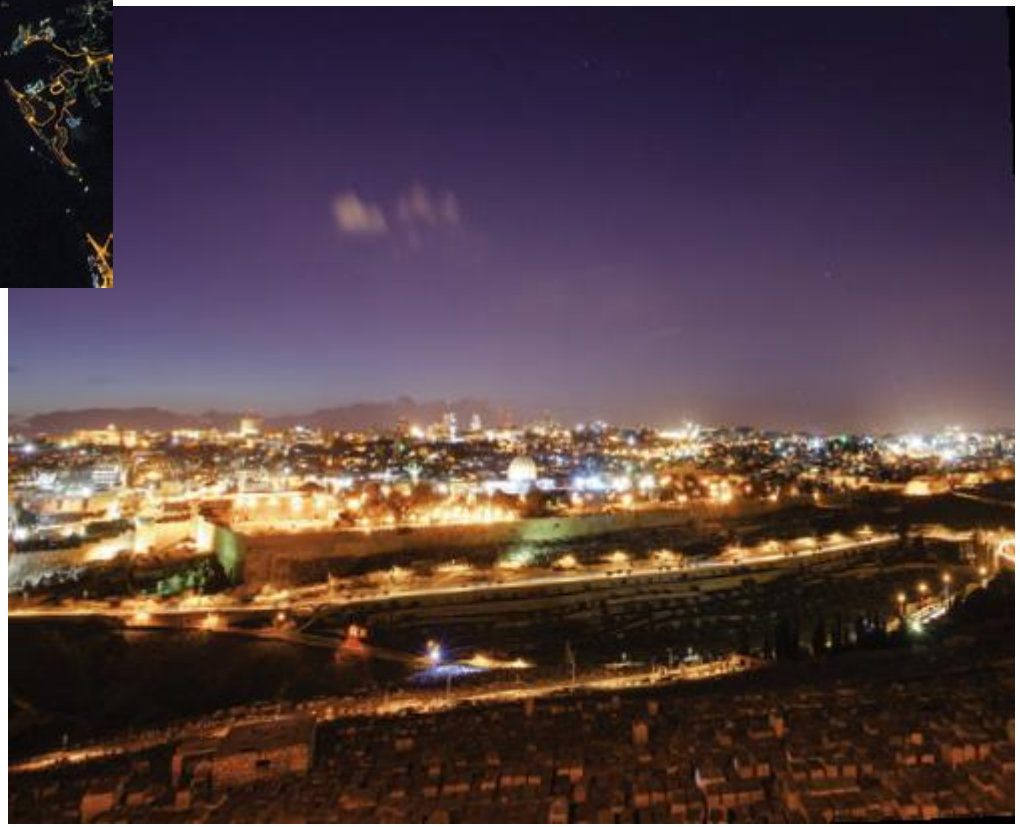
לשכת המהנדסים האדריכלים והאקדמאים במקצועות הטכנולוגיים בישראל

June, 2019

אברהמלה, פרופסור אברהם חיים מחלוצי המחקר על השפעותיו של האור על בריאות האדם והסביבה

Haifa – on the Mediterranean coast

Jerusalem



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- Artificial light at night (ALAN) is constantly increasing globally in urban areas

- Hence, wild animals are more exposed to ALAN due to proximity

- Birds adjust their circadian rhythms according to light which affects their physiology and behaviour

Widespread use of unnecessary lights in cities affects many species, including humans

Natural moon light = 0.25 lux
Indirect street light = 5 lux

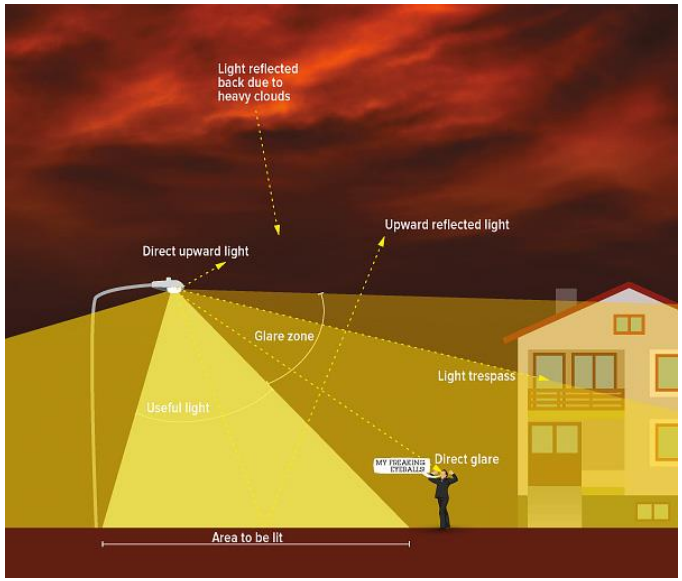


Image: Gocova

Examples for effects of ALAN on birds:

Alters singing & reproduction

Bedrosian et al., 2011

Increases feeding of nestlings

Bedrosian et al., 2013

Decreases melatonin → interrupts sleep

Bennie et al., 2014

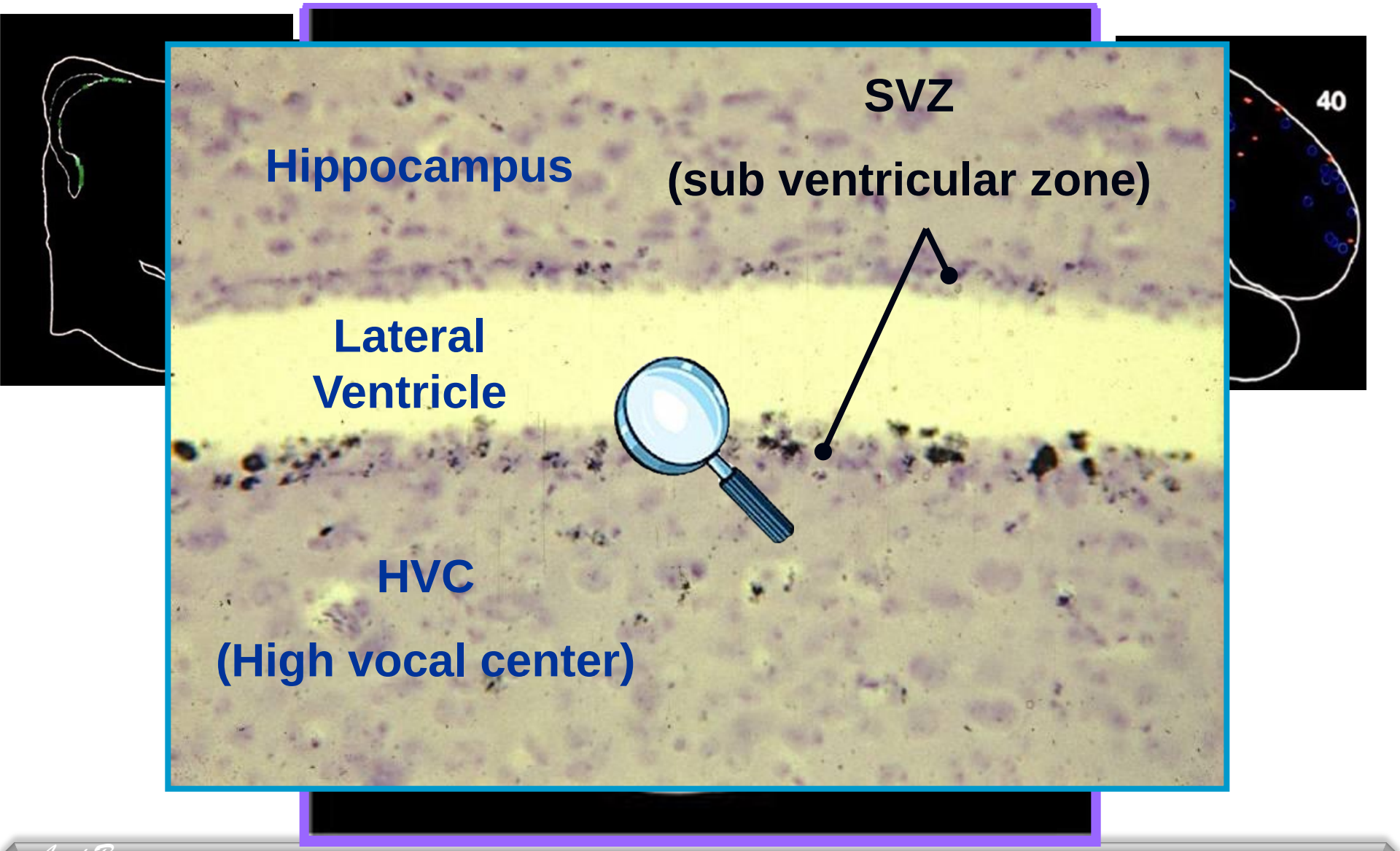
Does ALAN affect brain plasticity in birds' brains?

- Neurogenesis – production of new neurons
- Followed by neuronal migration & recruitment
- Turnover → replacement
- A form of brain plasticity: enables organisms to adjust to environmental changes
- Causal link to learning & memory

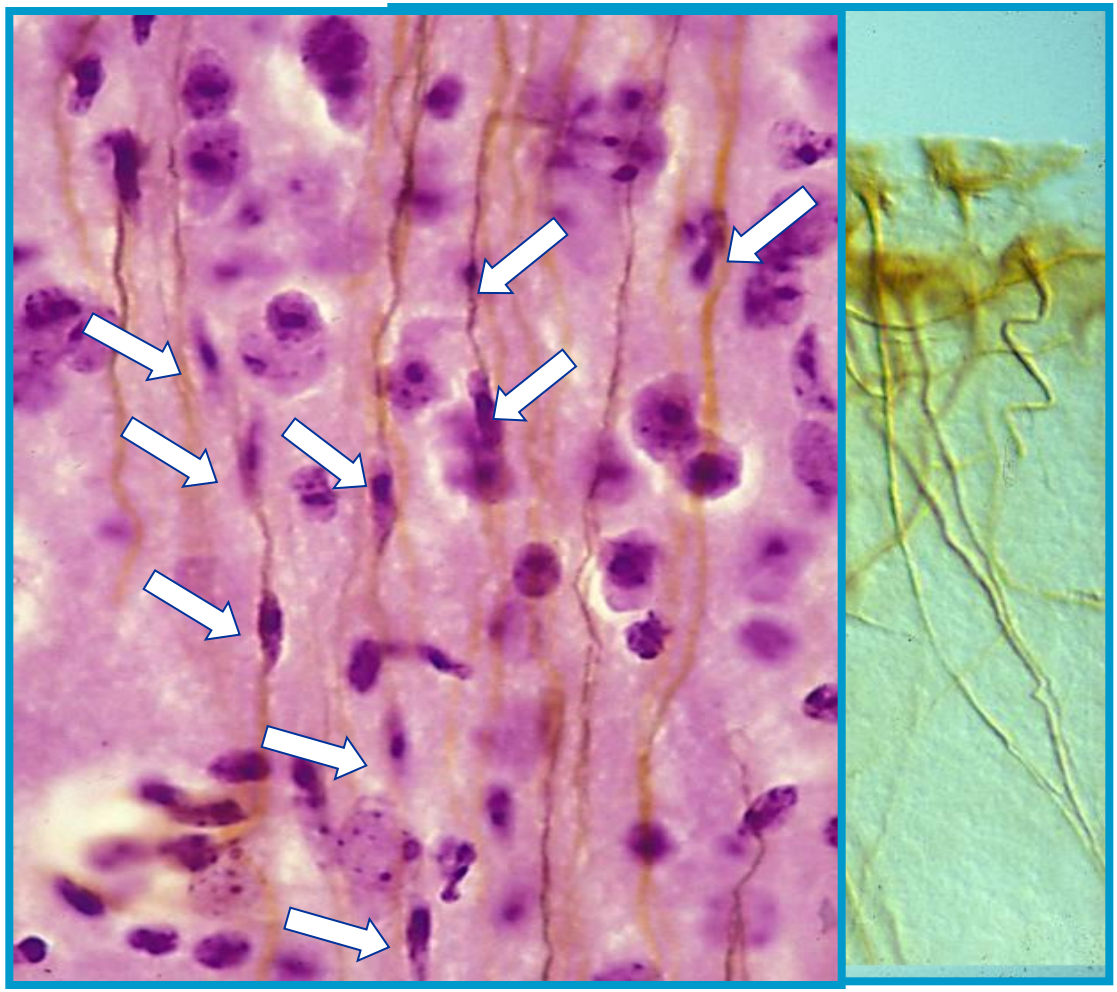
6 5 4 3 2 1 **Weeks**

Recruitment **Fate** **Migration**

Pictures by Nottebohm *et al.*



Neuroblasts migration Radial glia cells



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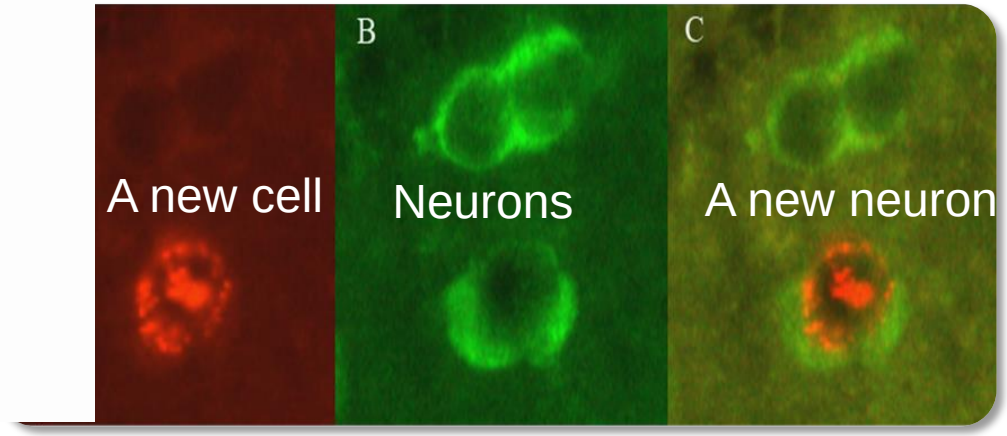

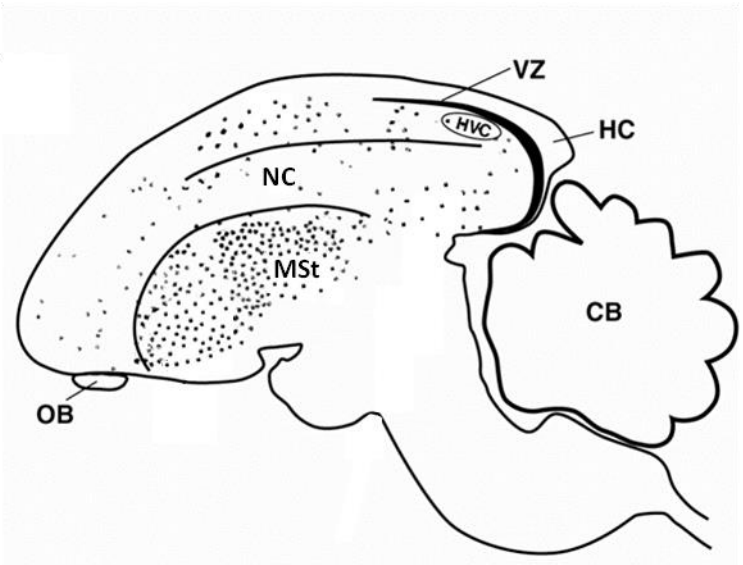

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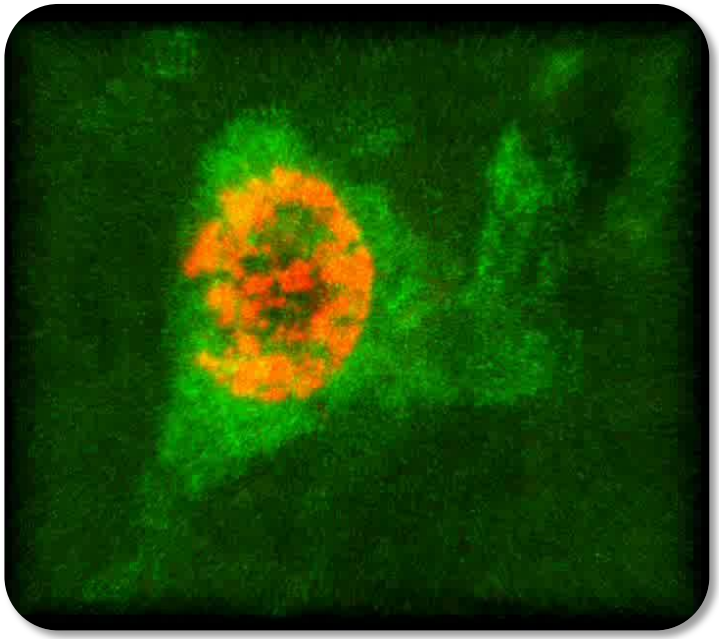


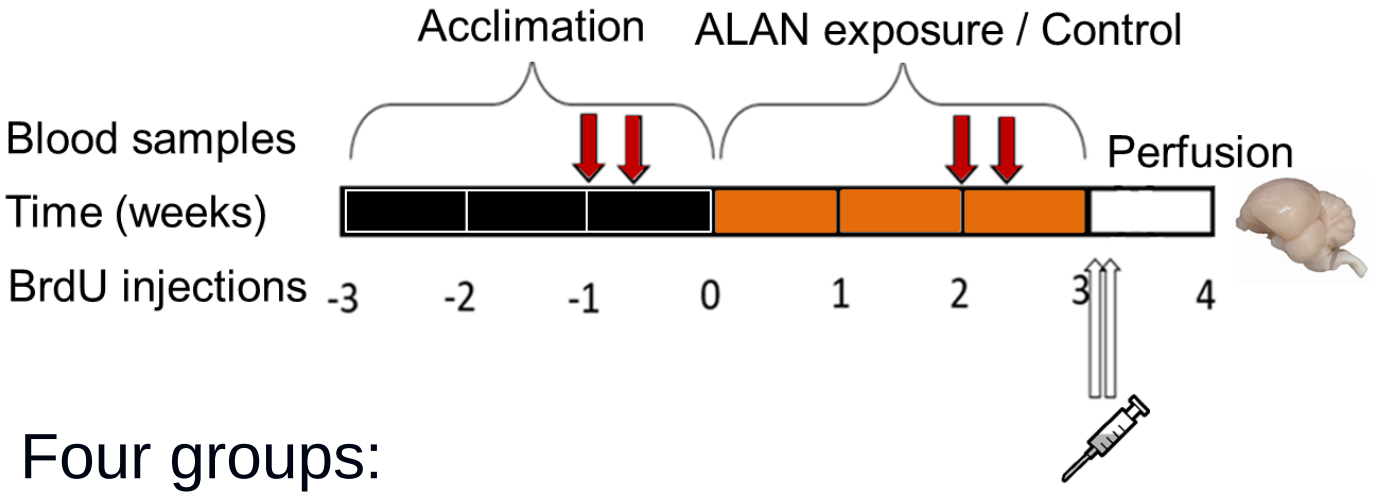
(Imaris 3D reconstruction, Y. Zillberstein)

Advantage of the bird model

zebra finches (*Taeniopygia guttata*)

- Diurnal animals, like humans
- widespread neurogenesis: new neurons constantly migrate from the VZ to several forebrain regions

Experimental Design



Four groups:

Control

6 w dark nights

dark nights

ALAN

3 w dark nights +
3 w ALAN:

0.5 lux

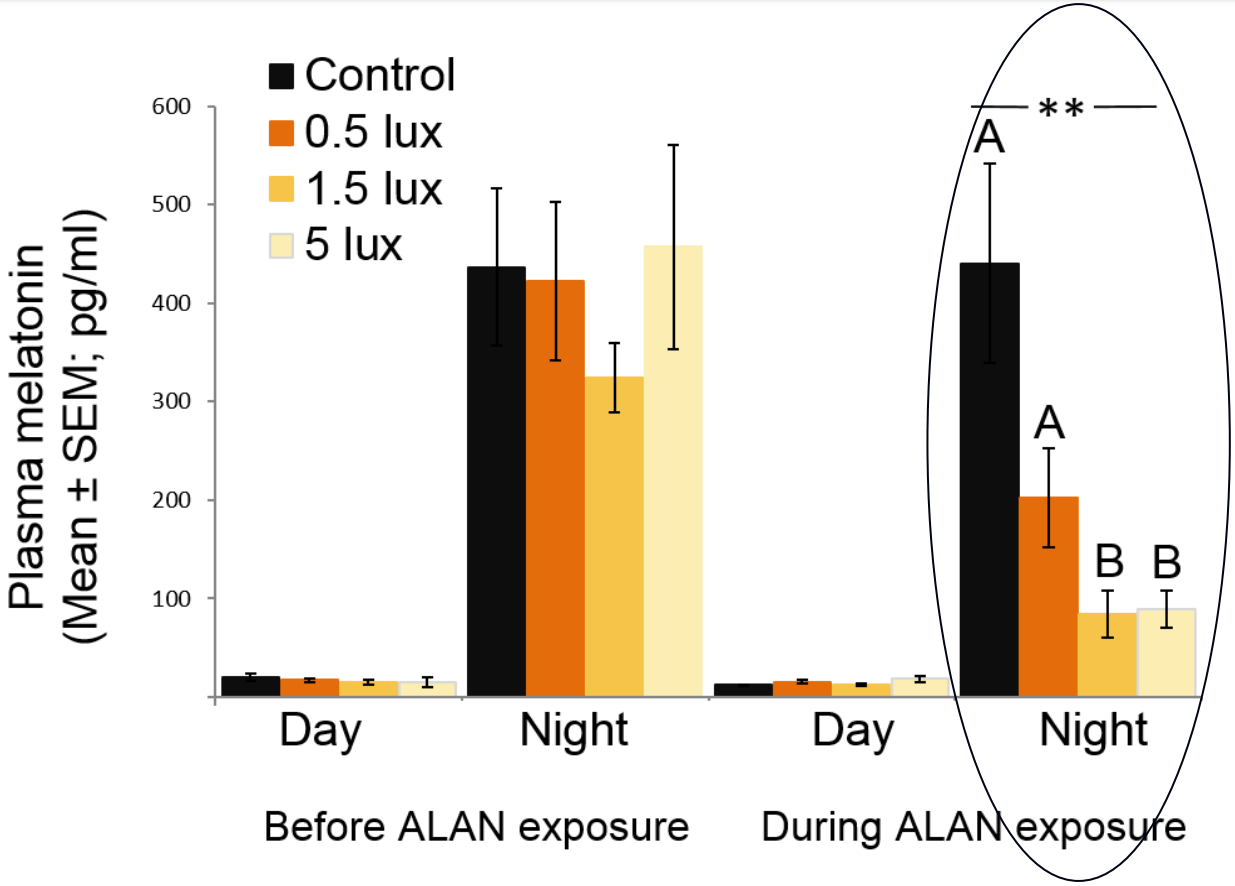
1.5 lux

5 lux

Experimental Design

Ecologically relevant intensities:

0.5 lux	forest next to a road
1.5 lux	forest next to car park
5 lux	trees close to street lights
dark nights	control



Radioimmunoassay

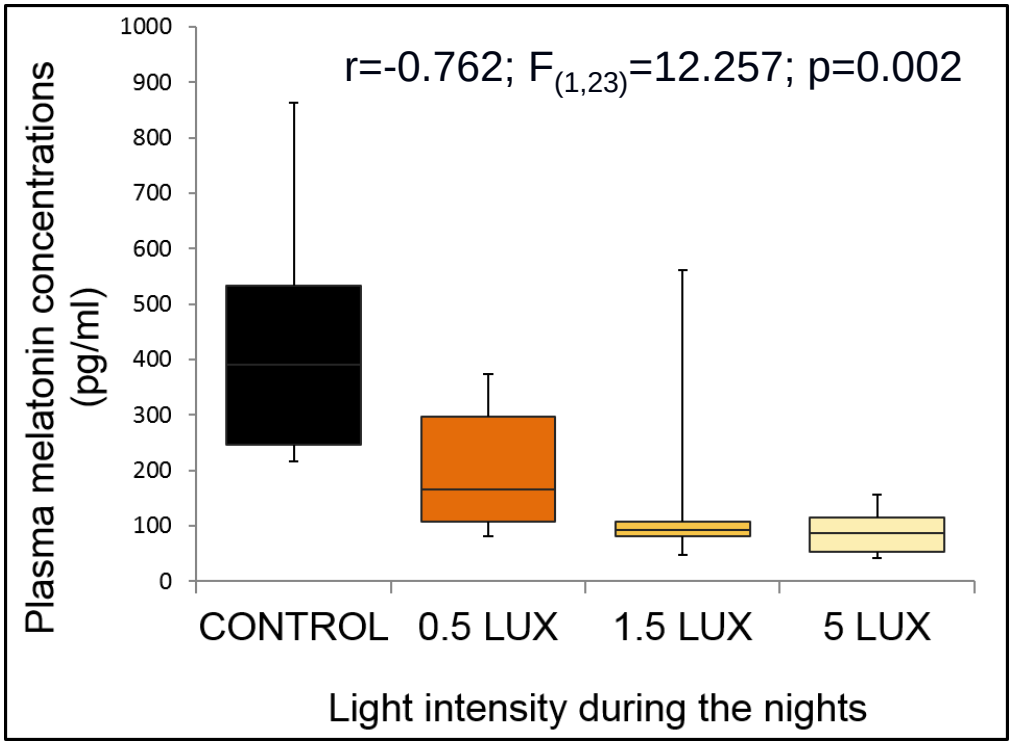
6 birds / group

$F_{(3,20)}=4.717$, $P=0.012$

ALAN suppresses melatonin production

In all ALAN groups

Dose-dependent effect



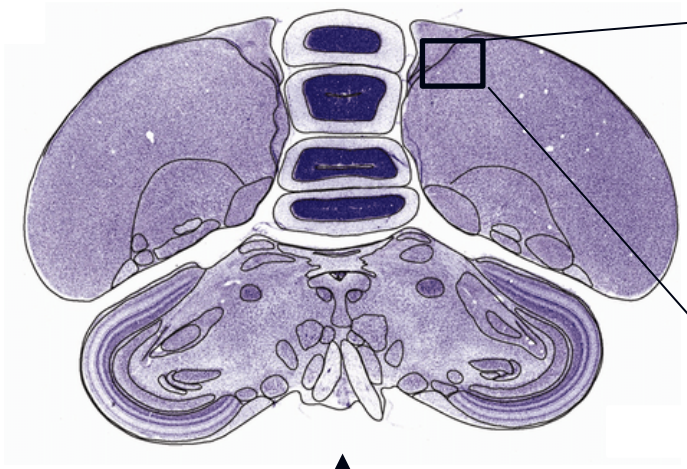
Nocturnal melatonin levels are negatively correlated with ALAN intensity

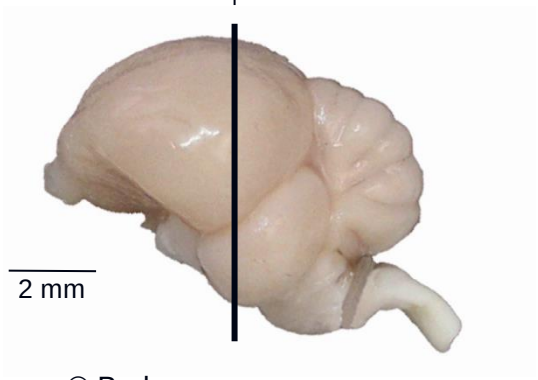
Range and variability of melatonin levels within each group decrease as ALAN increases

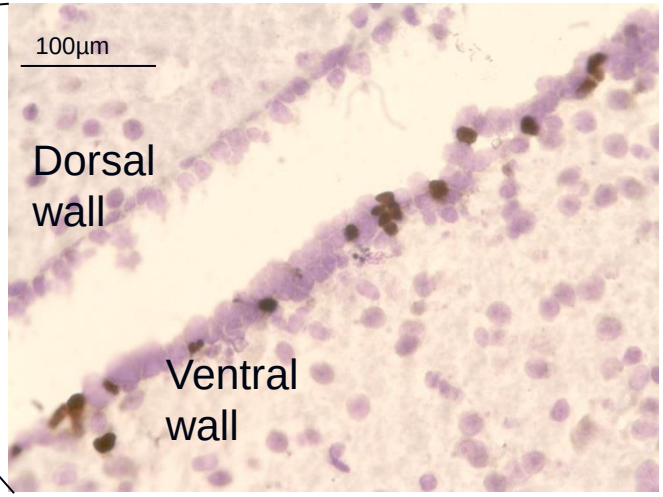
A diurnal species that is sensitive to low and ecologically relevant ALAN intensities

The inhibitory effect of low ALAN intensity on melatonin biosynthesis is not a characteristic feature only for nocturnal species, but is more generally relevant

Neurogenesis in the VZ







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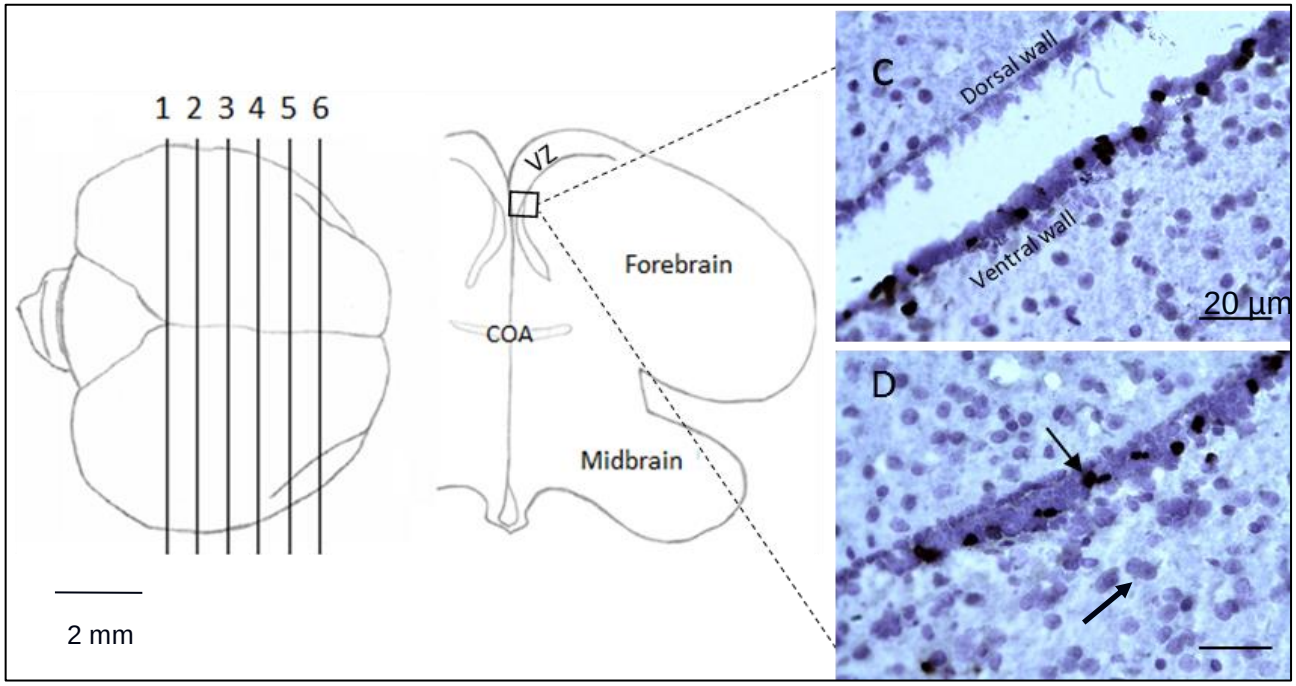
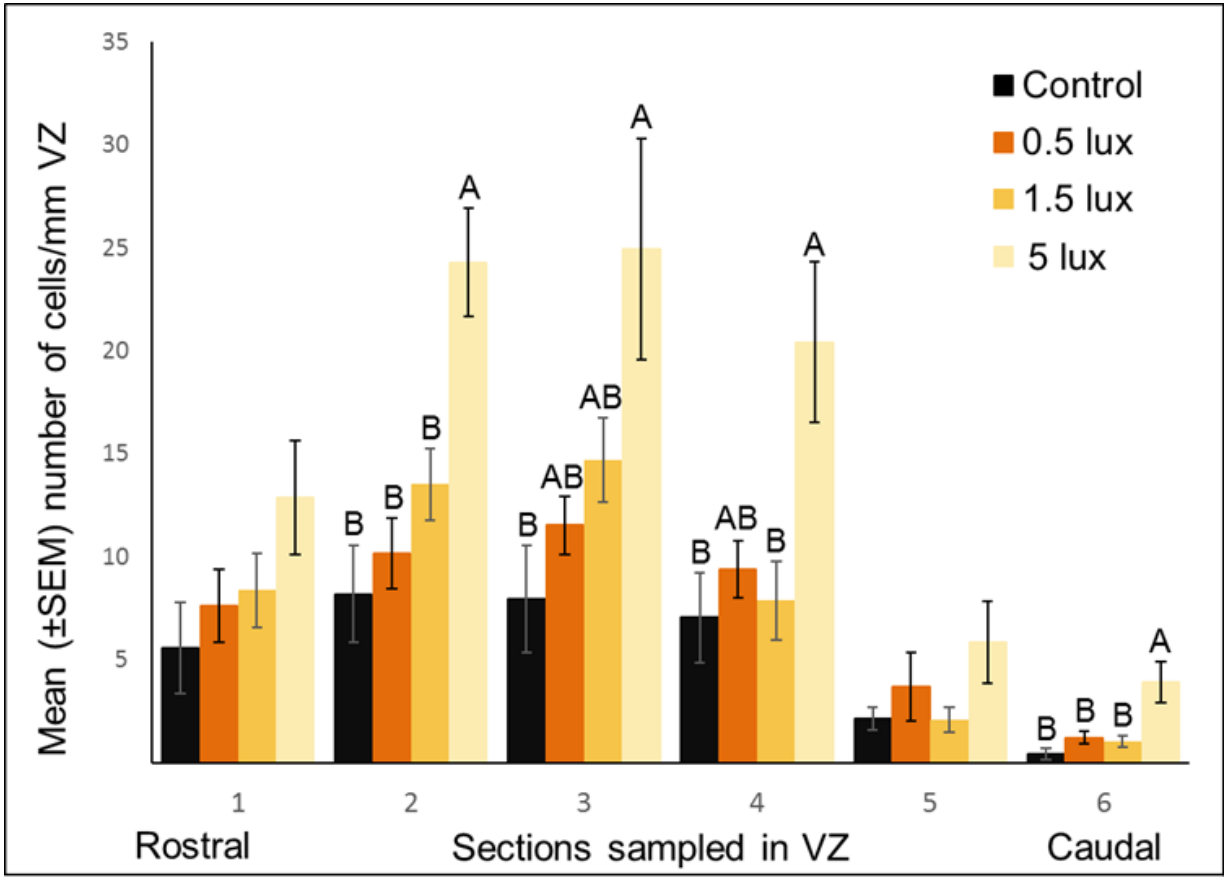
Neurogenesis in the VZ



Double-staining:

BRDU, a cell birth-date marker; brown/black; neurogenesis

Nissel staining, violet; neurons



Results from the ventral wall

6 birds / group

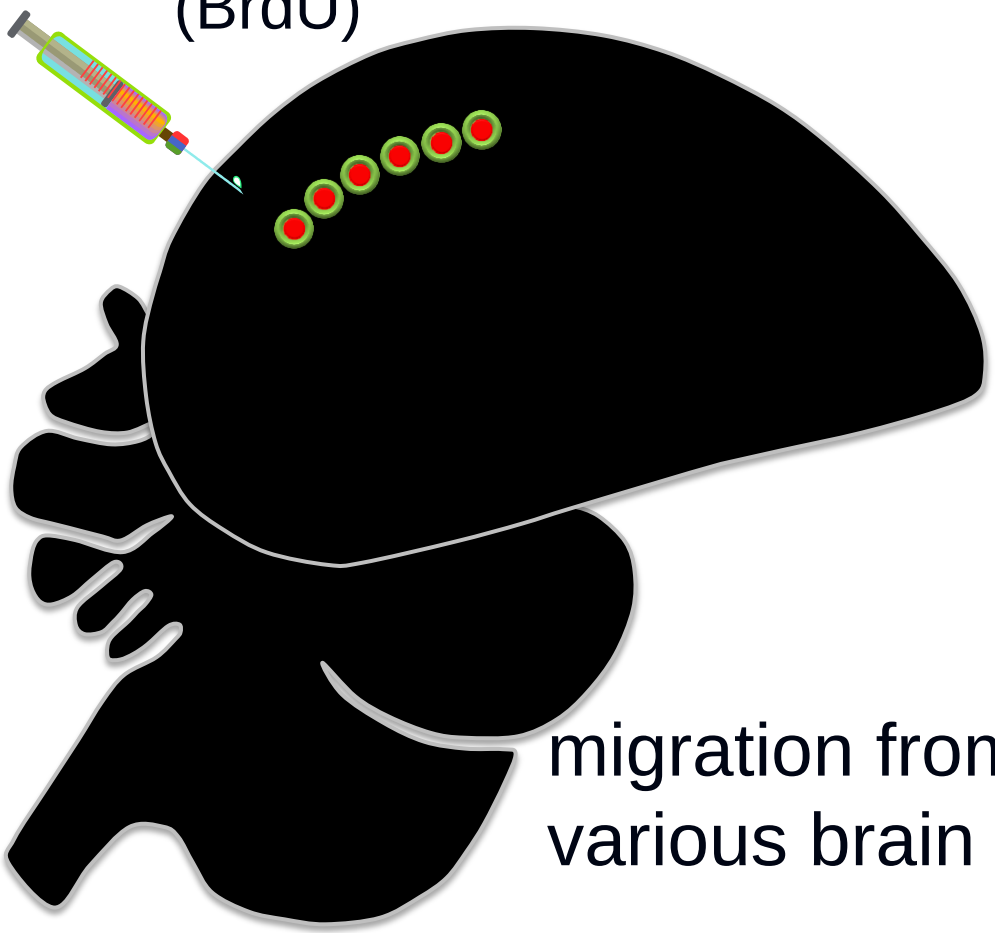
$F_{(3,20)}=8.832$, $p=0.0006$

ALAN increases neurogenesis

in specific locations along its rostral-caudal axis of the VZ

In a gradual and positive correlation with ALAN

Cell birth-date marker
(BrdU)



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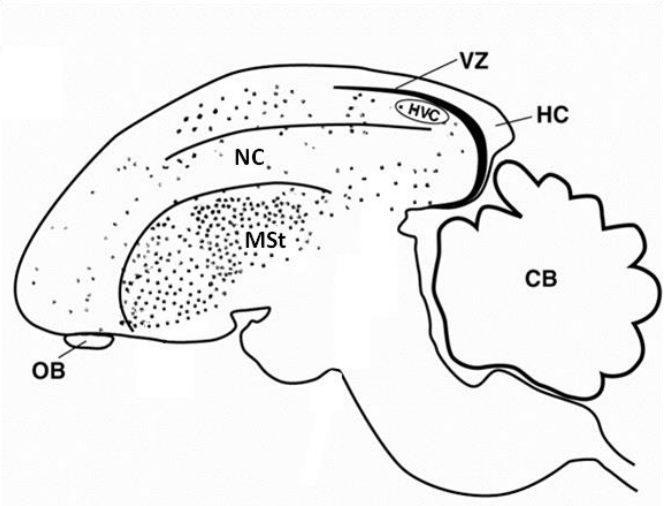
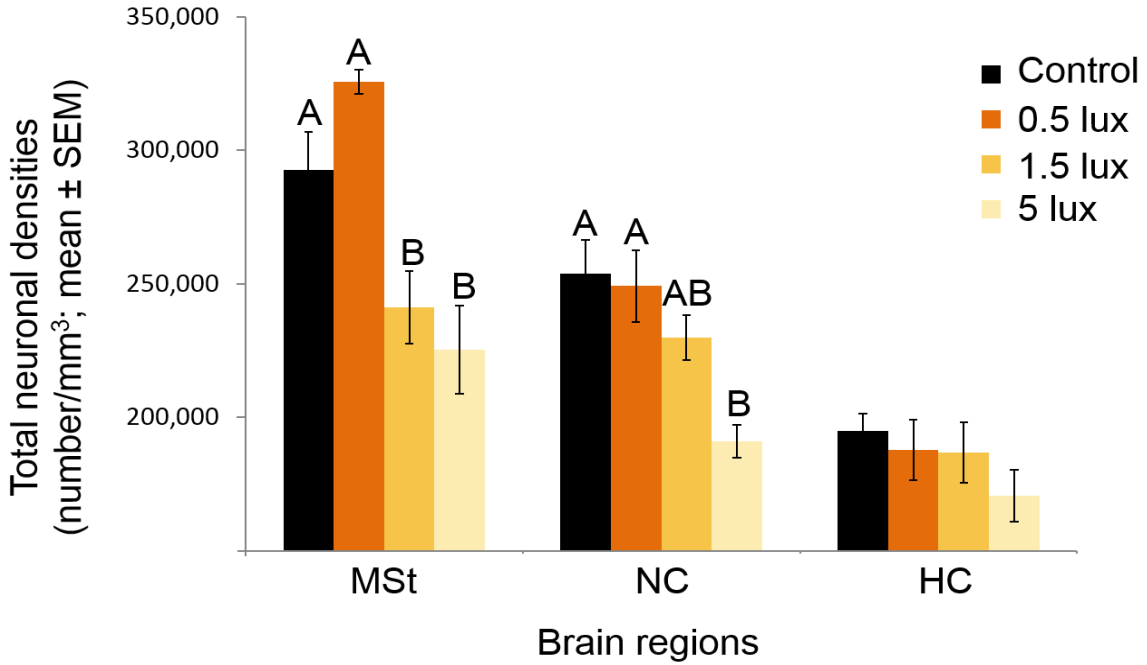
migration from the VZ to various brain regions

replacement →
constant total neuronal densities





MSt – Visual input processing ($F_{(3,20)}$=12.718, P=0.005)

NC – vocal communication ($F_{(3,20)}$=7.131, P=0.002)

HC – spatial information ($F_{(3,20)}$=1.054, P=0.391)

ALAN decreases neuronal densities → cell loss DESPITE the increase in proliferation

Summary and conclusions:

- First study about ALAN effect on neurogenesis in diurnal birds
- Ecologically relevant intensities
- ALAN increases proliferation
- ALAN decreased neuronal densities in target regions → the increased neurogenesis could be a wasteful process
- Our study adds to the compelling evidence that ALAN alters basic biological processes

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