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# **1. ARTIFICIAL LIGHT AT NIGHT (ALAN)**

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## **1.1. INTRODUCTION**

Bedrosian et al (2011) observed: "Species have been adapted to specific temporal and spatial niches optimising survival and reproduction; however, urbanisation by humans has dramatically altered habitats" (p468). A key part of human influence is light.

In approximately the last one hundred years, artificial light at night (ALAN) has come to dominate darkness with light in "places, times and at intensities at which it does naturally occur", and "with a spectrum that is different from those of sunlight, moonlight or starlight" (Gaston et al 2015) <sup>1</sup>.

Gaston et al (2015) stated the logical conclusion: "if biological systems are fundamentally shaped by light, and ALAN has changed the patterns of light in novel and extensive ways, it seems logical to predict that ALAN will have numerous biological impacts" (p1).

Scientific concern about ALAN (or light pollution <sup>2</sup>) dates back to the early twentieth century with work by William Rowan (1925).

Gaston et al (2015) outlined the challenges for researchers:

i) To distinguish the effects of the main different sources of ALAN - direct illumination, and artificial light scattered by cloud cover or from a clear sky (ie: "skyglow").

ii) The effect of the spectra of ALAN.

iii) How ALAN is "actually experienced by organisms". This includes variations based on sex, age or body size differences, for example, and between species (eg: birds vs mammals). Also whether there is a dose-

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<sup>1</sup> Other phrases for ALAN include a "perpetual full moon" (Longcore and Rich 2004), or a "perennial artificial moonlight" (Cinzano et al 2001).

<sup>2</sup> Light pollution has been defined as artificial sky brightness greater than 10% of natural night sky brightness, and it is estimated to affect over 80% of the European Union area and 60% of the USA (Le Tallec et al 2013).

response relationship.

Gaston et al (2015) noted that much "available knowledge is based on short-term experiments within one generation time (often days to weeks) that do not allow the consideration of response mechanisms, such as acclimation, adaptation, physiological, behavioural and even evolutionary compensatory mechanisms linked to environmental context and seasonal timing" (p4).

## 1.2. EFFECTS ON BIRDS

The photoperiod (ie: period of light in a 24-hour day) is a cue to organisms for daily and seasonal rhythms. ALAN has extended daylength as shown in earlier onset of dawn singing in songbirds (which is linked to males and reproduction), for instance (Dominoni and Partecke 2015)<sup>3</sup>.

Attaching light loggers to individual birds, for example, gives a measure of the average light intensity experienced at night.

Dominoni and Partecke (2015) captured one hundred European blackbirds (*Turdus merula*) (figure 1.1) in and around Munich in Germany between February and June in 2009-11, and attached a radio transmitter and a light logger, of which thirty-two were retrieved two weeks later. The light loggers recorded the light intensity every two minutes. The birds had territories in three areas - a rural forest, an urban park, and a business district. Birds in the latter area experienced a significantly longer subjective daylength of over thirty minutes as compared to the other two areas. The difference was even greater for birds captured during the breeding season (March) than outside (eg: May) (over sixty minutes earlier). The consequence is that the breeding season in urban blackbirds is earlier than in rural birds as the extended subjective daylength means males dawn sing earlier.

The researchers admitted two key limitations to their study:

a) ..."we did not know the locations of the birds throughout the day and night. This is a clear limitation, as individuals could behaviourally modulate daylength

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<sup>3</sup> Dominoni and Partecke (2015) pointed out changes in the daytime light environment because of urbanisation: "In particular, deforestation is one of the most apparent alterations of the landscape that precedes urban sprawl. As light intensity inside forest patches is usually lower than in the surrounding, more open land, we hypothesize that daytime light intensity would be higher in urban areas compared with nearby forested areas" (p2).



(Source: Malene Thyssen <https://commons.wikimedia.org/wiki/User:Malene>)

Figure 1.1 - Male blackbird singing.

exposure based on their sensitivity to light and/or their preference for spending their time in bright or dark areas. In addition, birds in different populations can consistently differ in some behavioural traits that can, in turn, consistently affect their light exposure. For example, song-post height has been shown to be higher in urban habitats compared with rural areas, which could have biased our results" (Dominoni and Partecke 2015 p7).

b) "Similarly, we could not control for the effect of other environmental variables that might have affected the activity of rural birds, upon which our analysis of subjective daylength has been based. For instance, although we have shown that weather conditions have little effect on the activity timing in our rural population, other studies have shown the opposite. In addition, the onset of activity in rural birds could strongly depend on factors such as food abundance, breeding density and reproductive status, which we did not record" (Dominoni and Partecke 2015 p7).

Da Silva et al (2015) found similar results with six songbird species (robin, blackbird, song thrush, great

tit, blue tit, chaffinch) recorded at twelve woodland sites that varied in light in south Germany in early 2012. Half of the sites were affected by street lighting.

The timing of the onset of the dawn chorus (in relation to sunrise) and the dusk chorus (in relation to sunset) were recorded for one hundred days. The choruses are linked to breeding as changes in the photoperiod produces changes in brain areas related to song control (Da Silva et al 2015).

Robins, blackbirds, and great tits began the dawn chorus significantly earlier in the year in the lighted than dark sites, while the blue tits showed this trend non-significantly. The chaffinch did not differ between sites, and the song thrush showed an opposite relationship. For the dusk chorus, only the song thrush and chaffinch did not start singing earlier in the year.

Da Silva et al (2015) summed up: "Thus, our study suggests that light pollution can lead to a faster seasonal development of the dawn and the dusk chorus. Interestingly, the effect was most pronounced in the robin and the blackbird, which are the two species that naturally sing earliest at dawn and that are most affected by light in terms of earlier daily singing, whereas absent in the chaffinch, a species whose daily timing of singing was not affected by light" (p7).

De Jong et al (2015) experimentally tested the effect of three different colours of street lighting (white, green and red) on nest boxes at eight sites in The Netherlands. In the breeding seasons of 2013 and 2014, data were collected on the pied flycatcher (*Ficedula hypoleuca*) and the great tit (*Parus major*). Information like first egg laying date, clutch size, and hatching date were recorded. Each previously dark site was illuminated from sunset to sunrise by one of three coloured streetlights, or was a dark control.

Some effects of the light were detected. In 2013, only great tits in green and white light laid their eggs significantly earlier than the control group<sup>4</sup>. While fledgling production (ie: young that successfully left the nest) was not affected by light in both species.

De Jong et al (2015) admitted that "it was not possible to control for settlement differences, because individual birds were free to choose whether or not to start breeding near the lamp posts. This choice opens the possibility that a non-random selection of the population breeds in nest-boxes under light at night. However, we

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<sup>4</sup> "In 2014, when spring was warmer and birds laid much earlier, there was no effect of light at night. An explanation for this difference could be that in cold years with a late season, such as 2013, photoperiod may play a more pronounced role in the onset of egg laying than in warm years with an early season [34], such that artificial night lighting would only affect laying date in the former" (De Jong et al 2015 p6).

did show that the breeding density of birds did not differ between light treatments, and birds that survived from 2013 to 2014 did not move to a particular light colour or away from the illuminated area to the dark control" (p7).

ALAN affects foraging behaviour. Many studies suggest a negative effect (eg: for ambush predators with excellent night vision), but there are also benefits.

Dwyer et al (2013) showed a clear example with a migratory shorebird, the common redshank (*Tringa totanus*) (figure 1.2). Birds like these need to feed during the day and night on the shorelines. During the day they find prey in and on the sand by sight (visual foraging), but at night they use tactile foraging (ie: probing with bill). The former strategy is preferred and gives the most profitable prey items.



(Source: Frebeck)

Figure 1.2 - A common redshank.

Dwyer et al (2013) radio-tagged and observed the birds on the industrialised Forth estuary in Scotland between November 2008 and March 2009. The light from the industrial complex created the equivalent of a full-moon night, and it allowed the birds to forage for significantly longer periods, and to forage visually at night.



Fledgling seabirds, like petrels and shearwaters in Hawaii, can be attracted by artificial light during their first flight to the sea from the cliff nest across or near urban areas, which leads to falling to ground to be killed by predators or die of starvation. "The main reason invoked to explain this attraction is that these species feed on bioluminescent squids, and inexperienced birds tend to search for lights (including artificial lights) to improve their chance of getting a meal" (Le Corre et al 2002 p93).

Le Corre et al (2002) quantified light-induced mortality of the Barau's petrel (*Pterodroma baroui*) (figure 1.3) and the Mascarene petrel (*Pseudodroma aterrima*) on Reunion Island in the Indian Ocean. Details of dead and living fallen birds were collected between 1996 and 1999 from reports by local people, who were asked to collect such birds for the island's museum.



(Source: B.navez; <https://commons.wikimedia.org/wiki/User:B.navez>)

Figure 1.3 - A fledgling Barau's petrel raised in captivity before release.

There were 2348 fallen petrels in the study period in urban areas (of which 94% were fledglings)<sup>5</sup>. Most

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<sup>5</sup> This number depends on the success of media campaigns to encourage participation by local people, and people's willingness to collect the birds.

birds were found in areas of the island where urban lights (ie: streetlight, sport installations, harbour infrastructures, individual houses, factories, and the airport) were most abundant.

The birds collected were used to calculate the proportion of fledglings lost (PL%) in the following equation:

$$PL\% = \frac{FL}{N \times FS \times BP}$$

where:

FL = total number of fledglings lost.

N = adult population size in pairs.

FS = fledging success: number of birds which successfully fledge out of the number of eggs laid per female.

BP = proportion of breeders in adult population.

Published data on petrels generally was used for FS (66% or 0.66; Simon 1984) and BP (89% or 0.89; eg: Imber 1985).

PL% was calculated, using 1999 data, for Barau's petrels (where FL = 596 and N = 5000) that 20% of fledglings were lost annually through attraction to artificial light <sup>6</sup>.

$$PL\% = \frac{596}{5000 \times 0.66 \times 0.89} = \frac{596}{2937} = 0.2 \text{ (20\%)}$$

### 1.3. EFFECTS ON MAMMALS AND OTHER ANIMALS

Approximately one-third of vertebrate and two-thirds of invertebrate species live exclusively or partial at night (Le Tallec et al 2013).

In terms of studying mammals, experiments with rats and bats found that light pollution leads to less activity, delayed daily emergence from nest, less foraging, and even reduced body growth in young (Le Tallec et al 2013).

One physiological system disrupted by ALAN is the immune system, as shown, for example, by Bedrosian et al (2011) with Siberian hamsters (*Phodopus sungorus*) (figure 1.4). Eighteen males kept at the Ohio State University breeding colony were exposed to four weeks of dim light (for eight hours at "night") (which was five times

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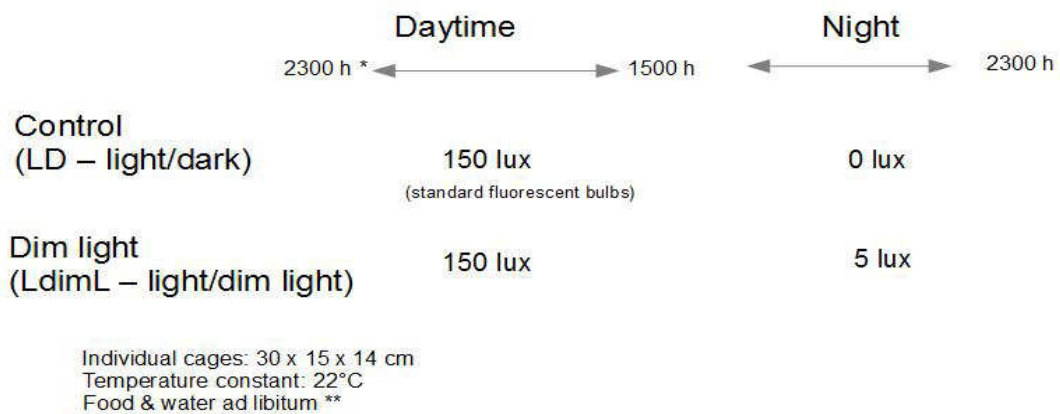
<sup>6</sup> If other figures are used, like FS = 35%, the PL% becomes closer to 40% (Le Corre et al 2002).



(Source: Simon Eugster)

Figure 1.4 - Siberian hamster.

brighter than a full moon), and four weeks of darkness at night (figure 1.5). The immune response was tested by the controlled introduction of antigens into the body (eg: bacteria in blood) to see the effect.



(\* = Eastern Standard Time (EST) in USA; \*\* = available as animal wanted)

Figure 1.5 - Design of experiment by Bedrosian et al (2011).

The dim light condition led to a significantly poorer inflammatory response, and killing of significantly fewer bacteria in the blood. These are both signs of a weakened immune system, which could lead to sickness and "potentially compromise survival... Thus, night-time light exposure could be considered an important contributing factor in species decline" (Bedrosian et al 2011 p470).

The potential impact of ALAN varies depending on the landscape. For example, lighting at a woodland edge can inhibit light-shy species movement comparable to lighting in an open area. This is known as "edge effects" (Laurance and Yensen 1991). Stone et al (2009), for instance, found less movement (and later leaving of roost) by the Lesser Horseshoe bat (*Rhinolophus hipposideros*) when high-pressure sodium lights were experimentally placed near roosts in southern England.

Street lighting can vary between the older orange high-pressure sodium (HPS) and low-pressure sodium (LPS) lights, and the newer light-emitting diodes (LEDs) and ceramic metal halide lights. The newer types produce a broader spectrum of light, which potentially attract more insects (and consequently bats).

This was confirmed by Stone et al (2015). They made use of the changing of street lighting from older to newer types by Cornwall County Council in south-west England (since 2009). In 2010, bat activity was measured at thirteen paired sites with LPS or metal halide lights. In terms of the consequences, the researchers pointed out:

that large scale replacement of LPS lights by white metal halide lights could alter the balance of species distributions through species-specific impacts, in this case by attracting more... [bats<sup>7</sup>]. While 'light tolerant' bat species may benefit from increased foraging on insects attracted to white street lights, altering the balance of predators and prey could have cascading ecosystem effects at lower trophic levels, with implications for ecosystem service provision. Bats feeding on tympanate moths may have a competitive advantage under white light as the moths' evasive behaviours are reduced, increasing their vulnerability to predation. Increased mortality at white lights will have consequences for other species in the ecosystem that depend on these insects for food and pollination. The attraction of 'light tolerant' bats to white light may also increase competition with other 'light-averse' bat species that forage in dark areas nearby (p5).

Mathews et al (2015), however, did not confirm the

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<sup>7</sup> Eg: Common pipistrelle bat (*Pipistrellus pipistrellus*) - mean passes: 414 with LPS light vs 878 with metal halide light (Stone et al 2015).



increased foraging activity in areas of ALAN generally in a large-scale study in England and the Republic of Ireland in 2007 and 2013 (that recorded over 265 000 bat calls at more than 600 locations).

Few experiments have been performed on primates. Le Tallec et al's (2013) work with the nocturnal grey mouse lemur (*Microcebus murinus*) (figure 1.6) is an exception. Eight adults at a laboratory breeding-colony in France were exposed to fourteen days of natural night light (equivalent to a full moon) (MOON condition), and fourteen days of light pollution (equivalent to a streetlight fifty metres away) (POLL condition). The latter brightness was about six times greater.



(Source: Photographer: Gabriella Skollar; editor: Rebecca Lewis)

Figure 1.6 - Grey mouse lemur.

The researchers concentrated on three areas of behaviour:

1. Radio transmitters implanted under the skin recorded body temperature and movement, which were used as the measures of the daily rhythms.

Body temperature was significantly higher in the POLL condition, and there was less movement during the night in this condition. "In addition, the daily phase of hypothermia (torpor) was delayed and less pronounced corresponding to a long-days phenotype, ie: a summer phenotype, suggesting an alteration of seasonal acclimatisation... These results suggest an alteration of thermoregulation related to exposure to light pollution. Similar results were obtained in the social vole (*Microtus socialis*) [Haim et al 2005], indicating that nocturnal light pulses may act as a stressor imposing a threat to the physiological homeostasis and, especially, negatively affect winter acclimatisation of thermoregulatory mechanisms probably by mimicking summer acclimatisation" (Le Tallec et al 2013 p5). Haim et al (2005) referred to "seasons out of time".

In terms of activity, Le Tallec et al's (2013) findings were similar to bats and rats (both nocturnal animals as well), and "could illustrate a desynchronisation of the activity patterns with the geophysical cycles of the environment or a negative light masking effect as described by Rotics et al (2011). Indeed, light stimulus can override an animal's internal biological clock and consequently modify the activity patterns. In nocturnal species, light stimulus suppresses activity" (Le Tallec et al 2013 p6).

2. Video cameras recorded when the animals emerged from their nest box to forage, and returned.

Emergence from the nest boxes was an average of 76 minutes later in the POLL condition, and the return 45 minutes later.

A delay of forty minutes was observed in a study of the flying squirrel (*Glaucomys volans*) (DeCoursey 1986). Nocturnal animals are less active at night as both an anti-predator strategy, and because light affects their visual abilities.

3. Food intake was calculated from the difference between provided and remaining food.

There was no difference in food intake between the two conditions, nor in food eaten immediately or taken to nest box.

This finding was different to previous studies with other species. For example, Darwin's leaf-eared mouse (*Phyllotis darwini*) carried ten times more food back to the nest in the artificial light than night condition, and overall consumed one-sixth less food (Vasquez 1994).

Le Tallec et al (2013) summarised their findings and the implications: "For the first time in a nocturnal primate, urban light pollution was demonstrated to modify the expression of biological rhythms, nocturnal and feeding behaviours and to have a negative impact on thermoregulation and potentially energy balance through changes in patterns of daily torpor bouts. Evidence of desynchronisation of both daily and seasonal biological rhythms could have deleterious consequences for animals, especially in terms of adaptation and anticipation of environmental changes. By altering behaviours, light pollution could affect the ability of individuals to effectively exploit their environment and its resources, and contribute to fragment the habitat particularly for photo-sensitive species. Ultimately, survival, reproduction and fitness of these species could be altered. At the ecological scale, the interspecific equilibrium could also be threatened" (p7).

Tuxbury and Salmon (2005) performed experiments with hatchling marine turtles to show the effect of shoreline ALAN. Hatchlings emerge from underground nests in the sand at night, and must crawl to the sea. This must be done as quickly as possible to avoid predators, dehydration, or exhaustion.

The process of "seafinding" is based on two visual cues (Tuxbury and Salmon 2005):

i) Light intensity - Light is reflected from the ocean and absorbed by land and vegetation, so hatchlings crawl towards the light.

ii) Horizon elevation - The hatchlings crawl away from the higher sand dunes towards the lower sea horizon.

ALAN interferes with the first of the visual cues leading to "disorientation" (crawling around in circles) and "misorientation" (crawling towards artificial light inland) (Witherington and Martin 1996).

Tuxbury and Salmon (2005) used hatchling loggerheads (*Caretta caretta*) and green turtles (*Chelonia mydas*) from nests in Florida. The turtles were placed individually in a circular arena (one metre in diameter) for testing.

In the first experiment, two book lights were placed at 45° apart to simulate street lighting at the beach. The majority of hatchlings moved in the direction of the lights (ie: towards an individual light or between the two of them).

The second experiment involved lighting and a silhouette (made to look like a vegetated dune behind the beach) placed at different angles. The crescent-shaped silhouettes were tested at four different elevations (ie: above the arena floor in relation to the hatchling's eyes). When the silhouette was at a high angle with the

lights, the loggerheads only oriented significantly away from the lights.

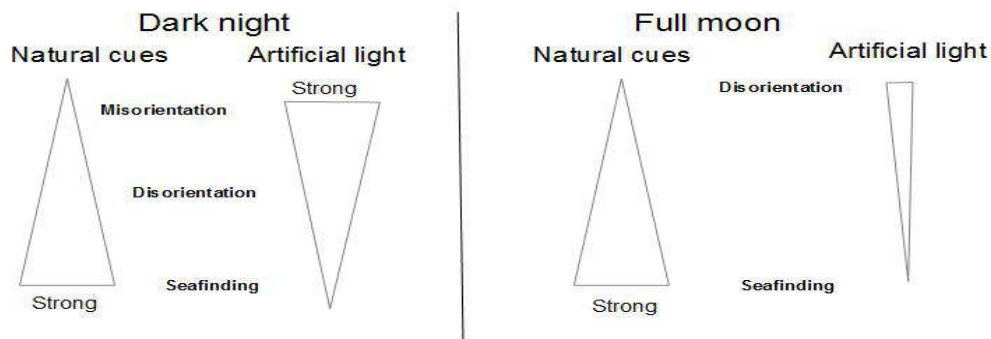
In the third experiment, orientation was tested with the two lights and a general background illumination (to simulate a full moon). Background illumination was created with a lamp above the arena, and was used in three conditions - lights and illumination both on, lights on and illumination off, and lights off but illumination on. Both species significantly oriented away from the lights. This showed that the hatchlings were unaffected by artificial lighting on the equivalent of a full-moon night, whereas Experiment 1 showed that in complete darkness the artificial light attracted them. The presence of the silhouette in Experiment 2 had a variable effect. Tuxbury and Salmon (2005) stated: "In summary, our data suggest that hatchling orientation at illuminated beaches depends upon interactions between lighting and the cues used naturally by the turtles to locate the sea" (p316).

The researchers asked: "Why does artificial lighting result in an inability to maintain direction under some conditions, and orientation toward light sources under other conditions" (Tuxbury and Salmon 2005 p314)? They offered the "cue competition hypothesis" as an answer. Natural light (moon) and ALAN are competing in their influence on the hatchlings' orientation. Thus:

a) Seafinding - This occurs when natural cues are strong and the ALAN weak.

b) Misorientation - This occurs when ALAN is strong and natural cues are weak on dark nights, but not full-moon nights.

c) Disorientation - This occurs on dark nights when natural cues and ALAN of equal strength, and when natural cues are weak on full-moon nights (figure 1.7).



(Based on Tuxbury and Salmon 2005 figure 4 p315)

Figure 1.7 - The cue competition hypothesis.



#### 1.4. HUMANS

Stevens and Zhu (2015) began:

The Sun, our primordial source, provides bright light during the day, and virtually no light at night. For several billion years, the solar signal has moulded an endogenous circadian rhythmicity in almost all life forms; for mammals this includes sleep-wake, core body temperature, metabolism and oscillations in gene expression and hormone production throughout the body. This endogenous rhythmicity has allowed for a physiological anticipation of the onset of day and the onset of night, a distinct competitive advantage in a dangerous world. From time immemorial, these circadian rhythms have been reset each day to precisely 24 h by exposure to the Sun.

Electric light, by contrast, is dim and ill-timed, disrupting all aspects of our endogenous circadian rhythmicity; its intensity and spectral content are often not adequate during the day for proper circadian resetting, and are too much during the night for a true 'dark' to be detected (p1).

"Circadian disruption" has been linked to a number of human diseases<sup>8</sup>, including, first of all, breast cancer (table 1.1), via nocturnal electric-light suppression of melatonin, for example, but also obesity, diabetes, and depression (table 1.2) (Stevens and Zhu 2015).

- Comparison of women working nightshift with dayshift (eg: Stevens et al 2014).
- Blind women (lower risk as no or limited electric lights used) (eg: Hahn 1991).
- Population level measurement of light at night by satellite (eg: Kloog et al 2001).

Table 1.1 - Example of types of study on artificial light and breast cancer.

One problem is that sleep deprivation experiments struggle to isolate the effect of disrupted sleep from exposure to light at night. "The physiological effects of light at night and sleep disruption have been 'proven' in the sense that there is general acceptance in the scientific community of its truth; ie: a consensus of experts. What has not been 'proven' is that electric light-at-night causally increases risk of cancer, or obesity, or diabetes, or depression" (Stevens and Zhu 2015 p2).

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<sup>8</sup> Known as "light-at-night" theory (Stevens and Zhu 2015).

- Self-reports of ambient bedroom light level, and of health (eg: Obayashi et al 2013).
- Experiments without night light (eg: camping in the Colorado wilderness; Wright et al 2013<sup>9</sup>).
- "Knockout mice" (ie: genetically engineered with "circadian gene(s)" "turned off").

Table 1.2 - Example of types of study on the effects of artificial light.

Most health studies in this area are "observational epidemiology" or quasi-experiments (ie: comparing two groups without manipulation of an independent variable), so, technically, do not establish causation in the way that an experiment could. But enough quasi-experimental studies with the same findings could be taken as proof of causation. The International Agency for Research on cancer (IARC), for instance, brings together experts to establish the consensus from such studies. They have five levels of confidence in the evidence as proof of causation - from the highest, (1) "human carcinogen", to the lowest, (4) "probably not a carcinogen". Smoking, for example, is rated as class 1 for human cancer (Stevens and Zhu 2015). The IARC in 2007 (Straif et al 2007) rated "shiftwork that involves circadian disruption" as class 2a ("positive carcinogen"). "The shift work classification was based on a compelling animal model, strong mechanistic data<sup>10</sup> and 'limited' epidemiological studies: the epidemiology was consistent with a causal relationship, but bias or confounding could not be entirely ruled out as possible explanations for the results" (Stevens and Zhu 2015 p2).

One effect of the introduction of electricity, that is forgotten in the modern world today, is, Ekirch (2006) argued, that "normal sleep" evolved as biphasic. This involved a "first sleep" of several hours, followed by a period of waking (in the dark or around a fire), and then a "second sleep" (Stevens and Zhu 2015).

#### 1.4.1. Circadian Misalignment

ALAN can lead to circadian misalignment, especially

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<sup>9</sup> "Wright et al (2013) conclude: 'Increased exposure to sunlight may help to reduce the physiological, cognitive and health consequences of circadian disruption'. They also point out: 'Natural sunlight is a stronger environmental zeitgeber or time cue for the internal circadian clock than is electrical lighting in the constructed environment'. In other words, people in the modern world not only get light during the night, they get far less light during the day inside electrically lit buildings. This can lead to circadian confusion and de-synchronisation of the rhythms throughout the body" (Stevens and Zhu 2015 p3).

<sup>10</sup> This "biomolecular effects of the agent that might lead to cancer" (Stevens and Zhu 2015).

for humans with irregular work schedules. Put simply, the rhythms of the body clock are unco-ordinated and out of sync with the natural day-night cycle.

The circadian clock may be linked to nearly half of all genes (Laber-Warren 2015). Zhang et al (2014) analysed tissue samples taken from twelve different organs in rats at various times of the 24-hour period. Activity in the cells was not steady over the period, but had busy and quiet phases as in most circadian processes. The most obvious of these being waking/sleep.

Li et al (2013) found that in vitro tissue taken from 89 post-mortem human brains showed daily patterns of activity and quiescence, except for individuals with depression.

One consequence of circadian misalignment is weight gain, as shown by inducing circadian misalignment in humans in the laboratory (eg: Scheer et al 2009), and keeping animals in constant light (Laber-Warren 2015).

Cognitive problems are also a consequence. For example, short-term memory impairments in doctors on night shift (Machi et al 2012), or rats struggling to learn a new maze when "jet-lagged" (McDonald and Hong 2013).

## 1.5. REFERENCES

Bedrosian, T.A et al (2011) Chronic exposure to dim light at night suppresses immune responses in Siberian hamsters Biology Letters 7, 468-471

Cinzano, P et al (2001) Moonlight without the moon Earth, Moon and Planets 85, 517-522

Da Silva, A et al (2015) Light pollution alters the phenology of dawn and dusk singing in common European songbirds Philosophical Transactions of the Royal Society B 370: 20140126

De Coursey, P.J (1986) Light-sampling behaviour in photo-entrainment of a rodent circadian rhythm Journal of Comparative Physiology A: Sensory, Neural and Behavioural Physiology 159, 161-169

De Jong, M et al (2015) Effects of nocturnal illumination on life-history decisions and fitness in two wild songbird species Philosophical Transactions of the Royal Society B 370: 20140128

Dominoni, D.M & Partecke, J (2015) Does light pollution alter daylength? A test using light loggers on free-ranging European blackbirds (Turdus merula) Philosophical Transactions of the Royal Society B 370: 20140118

Dwyer, R.G et al (2013) Shedding light on light: Benefits of anthropogenic illumination to a nocturnally foraging shorebird Journal of Animal Ecology 82, 478-485

Ekirch, A.R (2006) At Day's Close: Night in Times Past New York: W.W.Norton & Co

Gaston, K.J et al (2015) The biological impacts of artificial light at night: The research challenge Philosophical Transactions of the Royal Society B 370: 20140133

Haim, A et al (2005) Seasonality and seasons out of time: The

thermoregulatory effects of light interference Chronobiology International 22, 59-66

Hahn, R.A (1991) Profound bilateral blindness and the incidence of breast cancer Epidemiology 2, 208-210

Imber, M.J (1985) Origins, phylogeny and taxonomy of the gadfly petrel Pterodroma spp Ibis 127, 197-229

Kloog, I et al (2010) Night-time light level co-distributes with breast cancer incidence worldwide Cancer Causes Control 21, 2009-2068

Laber-Warren, E (2015) Out of sync Scientific American Mind September/October, 31-39

Lawrence, W.F & Yensen, E (1991) Predicting the impacts of edge effects in fragmented habitats Biological Conservation 55, 77-92

Le Corre, M et al (2002) Light-induced mortality of petrels: A four-year study from Reunion Island (Indian Ocean) Biological Conservation 105, 93-102

Le Tallec, T et al (2013) Light pollution modifies the expression of daily rhythms and behaviour patterns in a nocturnal primate PLoS ONE 8, 11, e79250 (Freely available at <http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0079250>)

Li, J.Z et al (2013) Circadian patterns of gene expression in the human brain and disruption in major depressive disorder Proceedings of the National Academy of Sciences, USA 110, 24, 9950-9955

Longcore, T & Rich, C (2004) Ecological light pollution Frontiers in Ecology and the Environment 2, 191-198

Machi, M.S et al (2012) The relationship between shift work, sleep, and cognition in career emergency physicians Academic Emergency Medicine 19, 1, 85-91

Mathews, F et al (2015) Barriers and benefits: Implications of artificial night-lighting for the distribution of common bats in Britain and Ireland Philosophical Transactions of the Royal Society B 370: 20140124

McDonald, R.J & Hong, N.S (2013) How does a specific learning and memory system in the mammalian brain gain control of behaviour? Hippocampus 23, 11, 1084-1102

Obayashi, K et al (2013) Exposure to bright light at night and risk of depression in the elderly Journal of Affective Disorders 151, 331-336

Rotics, S et al (2011) Light masking in the field: An experiment with nocturnal and diurnal spiny mice under semi-natural field conditions Chronobiology International 28, 70-75

Rowan, W (1925) Relation of light to migration and developmental change Nature 115, 494-495

Scheer, F.A.J.L et al (2009) Adverse metabolic and cardiovascular consequences of circadian misalignment Proceedings of the National Academy of Sciences, USA 106, 11, 4453-4458

Simon, T.R (1984) A population model of the endangered Hawaiian dark-rumped petrel Journal of Wildlife Management 48, 1065-1076

Stevens, R.G & Zhu, Y (2015) Electric light, particularly at night, disrupts human circadian rhythmicity: Is that a problem? Philosophical Transactions of the Royal Society B 370: 20140120

Stevens, R.G et al (2014) Breast cancer and circadian disruption from electrical lighting in the real world CA: A Cancer Journal for Clinicians 64, 207-218

Stone, E.L et al (2009) Street lighting disturbs commuting bats

Current Biology 19, 1123-1127

Stone, E.L et al (2015) The impacts of new street light technologies: Experimentally testing the effects on bats of changing from low-pressure sodium to white metal halide Philosophical Transactions of the Royal Society B 370: 20140127

Straif, K et al (2007) Carcinogenicity of shift-work, painting, and fire-fighting Lancet Oncology 8, 1065-1066

Tuxbury, S.M & Salmon, M (2005) Competitive interactions between artificial lighting and natural during seafinding by hatchling marine turtles Biological Conservation 121, 311-316

Vasquez, R.A (1994) Assessment of predator risk via illumination level: Facultative central place foraging in the cricetid rodent *Phyllotis darwini* Behavioral Ecology and Sociobiology 34, 375-381

Witherington, B.E & Martin, R.E (1996) Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches Florida Marine Research Institute Technical Report TR-2

Wright, K.P et al (2013) Entrainment of the human circadian clock to the natural light-dark cycle Current Biology 23, 1554-1558

Zhang, R et al (2014) A circadian gene expression atlas in mammals: Implications for biology and medicine Proceedings of the National Academy of Sciences, USA 111, 45, 16219-16224

## **2. RESILIENCE AND VULNERABILITY**

- 2.1. Differential susceptibility
- 2.2. Poverty
- 2.3. References

### **2.1. DIFFERENTIAL SUSCEPTIBILITY**

Resilient children are able to cope with life's misfortunes, whereas environmentally sensitive (ES) children are "especially vulnerable to the ill effects of hardship" (Belsky 2015). The latter have been called "orchid children" ("prone to wither in harsh conditions") as opposed to "dandelion children" ("able to put down roots and survive in the rockiest soil") (Belsky 2015) <sup>11</sup>.

ES children are more likely to develop psychological problems than the general population, but they benefit most from extra help, in a way that resilient children do not. Belsky (2015) called this "differential susceptibility to rearing experience" <sup>12</sup>.

Pluess and Belsky (2009) analysed the data from the Study of Early Child Care and Youth Development in the USA, which covered 1300 children in ten cities between 1991 and 2007. Interviews with the mothers were made at 1, 6, 15, 24, 36, 54, and 60 months old. Temperament was scored at one and six months old using the Infant Temperament Questionnaire (Carey and McDevitt 1978), while childcare quality was scored from five observations of interactions with the primary caregiver. At five years old, there was a clear pattern among ES or difficult-temperament children <sup>13</sup>. Those well cared for were rated best behaved by teachers, but the poorly cared for were the most aggressive and disobedient in class <sup>14</sup>. The researchers stated "that it is not just that negatively-emotional infants are more at risk of succumbing to the adverse effects of problematic rearing environments, but that they also reap a greater benefit from supportive

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<sup>11</sup> There is a parallel with the idea of luck. Based on research with over seven hundred individuals who perceived themselves as lucky, unlucky, or neither, Wiseman (2003) distinguished four psychological differences between the extremes. "Lucky" individuals notice chance opportunities, use their intuition in decision-making, try to fulfil their expectations of the future, and see the positive in any situation, even negative ones.

<sup>12</sup> From an evolutionary point of view, in "a continually changing and essentially unpredictable environment the transmission of one's genes will be facilitated by a diversification of investments, that is, offspring with a differential susceptibility to various environments" (Bakermans-Kranenburg et al 2008 p293).

<sup>13</sup> These infants "fuss a lot, have trouble sleeping and are easily upset by new situations" (Belsky 2015).

<sup>14</sup> Thomas et al (1968) were the first to formalise that infant characteristics (temperament) interacts with parenting to produce the outcome for the child generally.

family and childcare environments" (Pluess and Belsky 2009 p401) <sup>15</sup>.

Cassidy et al (2011) showed similar results in a quasi-experiment that allocated poor mothers of newborns to a parenting intervention programme or not. The "Circle of Security" programme taught parenting techniques to promote secure mother-child attachments, whereas the control group discussed parental concerns. After the intervention programme, babies were classed as more secure, but only if as newborns they were rated by the mothers as more irritable. The benefits were not evident for newborns rated as less irritable.

Being an ES child has been linked to maternal stress during pregnancy and the development of a more sensitive nervous system, a more reactive amygdala, certain genes (eg: linked to dopamine) or epigenetics (Belsky 2015) <sup>16</sup>.

For example, general research has found that the version of the serotonin transporter gene 5-HTTLPR and the environment interact (eg: a short version and negative experiences lead to depression). But Kochanska et al (2015) found that children with a short version of the gene and classed as highly anger prone, who had been parented well had positive development compared to negative development among poorly-parented short-gene carriers <sup>17</sup>. Parenting had no relationship for carriers of the long version of the gene (Belsky 2015).

Brody et al (2015) reported a similar pattern among African-American adolescents. Using racism experienced as the measure of environmental adversity, carriers of the short version of the 5-HTTLPR gene who were least aggressive had had the least negative experiences, and the most aggressive the most racism experienced. This pattern applied to boys but not girls (Belsky 2015).

Another gene that has been studied is a dopamine receptor gene (DRD4), of which the long version is a risk for attention-deficit/hyperactivity disorder. In a Dutch

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<sup>15</sup> "The characteristics of difficult temperament - low adaptability, high activity, low emotional regulation - may be indicators of a general heightened sensitivity of the nervous system to environmental stimuli which results in children becoming easily overwhelmed even in just modestly adverse environments, but also in benefiting disproportionately in supportive ones from care that enables them to regulate their proneness to distress and gather information from the world around them" (Pluess and Belsky 2009 pp401-402).

<sup>16</sup> There has been discussion about whether resilience is biological/innate or learned/social. Trying to distinguish the biological from the social, Callard and Fitzgerald (2015) felt, depended "on a strikingly naive view of the actual things of the world; as if people had bits that were distinctively social, and bits that were distinctively natural - as if they were not, in fact, endlessly torqued concatenations of disposition and agency, both human and non-human, and vague, half-glimpses of which we have only recently decided to encumber with the inadequate terms 'biological', 'social', 'psychological', and so on" (p8).

<sup>17</sup> This was based on 100 families observed at 25, 38, 52, 67 and 80 months old for parent-child interactions, and at age 10 years old self and parental reports of behaviour.

study <sup>18</sup>, Bakermans-Kranenburg et al (2008) found that toddlers with the long version and exhibiting behavioural problems responded most to their parents being trained to use sensitive discipline techniques <sup>19</sup>. One hundred and fifty-seven 1-3 year-olds chosen for high levels of externalising behaviour (eg: tantrums, defiance, aggression). About half (n = 83) were randomly allocated to the intervention group, and the remainder to the control group. The intervention group received VIPP in six home visits, while the control group had six telephone calls only.

In the USA, Beach et al (2014) studied an intervention programme called "Adults in the Making" (AIM) with 300 rural African-American families between 2004 and 2010 <sup>20</sup>. Parents were taught positive skills to help their teenage children <sup>21</sup>. Teenagers with the long version of the DRD4 gene, whose parents had attended AIM classes, were least likely to substance abuse, even two years after the programme ending (Belsky 2015).

Concentrating on specific genes as the basis of ES children is too narrow, so researchers have created the polygenetic plasticity index to cover a number of known risk genes. For example, Belsky and Beaver (2011) reported designing an index based on five "plasticity alleles". Highest scores with good parenting (measured as maternal involvement, engagement and attachment) predicted self-control (in attention, feelings and behaviour) as an adolescent in the "Add Health" <sup>22</sup> project in the USA <sup>23</sup>. A similar index and parenting has been found to predict adult romantic relationship success (Masarik et al 2014).

## 2.2. POVERTY

Resilience, in relation to poverty, refers to individuals and communities being able to withstand setbacks, and even use the problems as a means of

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<sup>18</sup> SCRIPT study (Screening and Intervention of Problem behaviour in Toddlerhood).

<sup>19</sup> Video-feedback Intervention to promote Positive Parenting (VIPP) involved video-recording the parent and child interacting, and then providing feedback to encourage positive interactions by the parent.

<sup>20</sup> Measures were taken at 17 years old (baseline), and each year up to 22 years old.

<sup>21</sup> A non-supportive parenting (NSP) index was developed from self-reports of parent-child conflict (with items like "You and your child's arguments are left hanging and unsettled"), and parent support. A high score indicated high NSP.

<sup>22</sup> National Longitudinal Study of Adolescent Health (begun in 1994-5 with 1586 adolescents).

<sup>23</sup> Belsky and Beaver (2011) observed that "it could be that certain environmental exposures, including parenting experience, result in certain genes being more or less likely to be expressed, thereby influencing downstream physical, physiological, behavioural and/or psychological development".



positive change (Harrison 2013)<sup>24</sup>. This "offers a different perspective from 'deficit' models of social and economic exclusion, and the paradigms of passivity or dependency that are often embedded in that approach" (Batty and Cole 2010 quoted in Harrison 2013 pp98-99).

Viewing resilience in this way, however, "creates an expectation that people should 'bounce back'" (Harrison 2013), and the focus becomes why certain individuals do not.

Harrison (2013) reported interviews with individuals living in poverty in 2010 in a town in southern England (Newhaven, Sussex). What emerged were individuals coping with stigmatisation of their community and their status, and the normative assumptions of "bouncing back". For example, one informant reported that public sector workers "spoke to me like I was absolutely nothing", and another said "they treat us like rubbish".

The recent recession was "not experienced as a 'shock', but was rather 'more of the same'", as summed up by "Jane": "we're poor and we have always been poor. I suppose we always will be poor" (Harrison 2013 p105).

The positive resilience view emphasised cutting back and adapting purchases, for example, but ignored the impacts on health (physical and mental). Harrison (2013) summed up: "The material from Newhaven demonstrates that, in the face of recession, resilience is not a bottomless pit that can be continually replenished. In 'coping', people (like Jane) may well be undermining their own health, disposing of assets and eroding their capacity to do the same in the future - something that may well be overlooked in over-romantic celebrations of resilience" (p109).

### 2.3. REFERENCES

Bakermans-Kranenburg, M.J et al (2008) Experimental evidence for differential susceptibility: Dopamine D4 receptor polymorphism (DRD4 VNTR) moderates intervention effects on toddlers' externalising behaviour in a randomised controlled trial Developmental Psychology 44, 1, 293-300

Beach, S.R.H et al (2014) Non-supportive parenting effects telomere length in young adulthood among African-Americans: Mediation through substance abuse Journal of Family Psychology 28, 6, 967-972

Belsky, J (2015) The upside of vulnerability Scientific American Mind September/October, 40-45

Belsky, J & Beaver, K.M (2011) Cumulative-genetic plasticity, parenting and adolescent self-regulation Journal of Child Psychology and Psychiatry 52, 5, 619-626

Brody, G.H et al (2015) Differential susceptibility analysis reveals

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<sup>24</sup> Harrison (2013) distinguished the use of resilience as a means to place the responsibility on the individual as opposed to vulnerability, which "suggests moral responsibilities for those in positions of power towards those who are less powerful" (p110).

the "who and how" about adolescents' responses to preventive interventions: Tests of 1st- and 2nd-generation gene x intervention hypotheses Development and Psychopathology 27, 1, 37-49

Callard, F & Fitzgerald, D (2015) Rethinking Interdisciplinarity Across the Social Sciences and Neurosciences Basingstoke: Palgrave Macmillan

Carey, W.B & McDevitt, S.C (1978) Revision of the Infant Temperament Questionnaire Pediatrics 61, 735-739

Cassidy, J et al (2011) Enhancing infant attachment security: An examination of treatment efficacy and differential susceptibility Development and Psychopathology 23, 1, 131-148

Harrison, E (2013) Bouncing back? Recession, resilience and everyday lives Critical Social Policy 33, 1, 97-113

Kochanska, G et al (2015) Developmental interplay between children's biobehavioural risk and the parenting environment from toddler to early school age: Prediction of socialisation outcomes in pre-adolescence Development and Psychopathology 27, 3, 775-790

Masarik, A.S et al (2014) For better and for worse: Genes and parenting interaction to predict future behaviour in romantic relationships Journal of Family Psychology 28, 3, 357-367

Pluess, M & Belsky, J (2009) Differential susceptibility to rearing experience: The case of childcare Journal of Child Psychology and Psychiatry 50, 4, 396-404

Thomas, A et al (1968) Temperament and Behaviour Disorders in Children New York: New York University Press

Wiseman, R (2003) The Luck Factor London: Century