Arizona State University Rikkyo University University of Tsukuba

AAP Flash Japon

IRSN INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

Faire avancer la sûreté nucléaire

FREEBIRD Project- Fukushima Radiation Exposure & Effects in BIRD populations

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(IRSN/PRP-ENV/SERIS/LECO)

Workshop on uncertainties in field studies on chronic low level effects due to radiation - CEH Lancaster Feb. 4-6th 2013

Why the FREEBIRD project?

- From Chernobyl (26 April 1986)…

➡ Many studies performed under **controled condition** (lab.) to measure the effects of ionizong radiations on **non-human organisms**…
…but the **majority** have been realized under **acute exposure condition**.

↪ Therefore, from these studies, it is **difficult** to **identify** and **predict** the eco-physiological and evolutionary **consequences** of **ionizing radiations under chronic exposure** on **individuals in the wild**.

➡ Some studies have thus been conducted under **natural conditions**, mainly from **bird populations**.

↪ However, **two limitations** exist in these studies:

- have been performed **20 years** after the nuclear accident…
- …from **background radiation level measurements** highly **disputed**;

Effects of ionizing radiation exposure on wild organisms

CHERNOBYL

RADIATION EXPOSURE

20 years after the accident

natural selection, adaptation

Lack of immediate and/or short-term data

PHYSIOLOGY

PHENOTYPIC EXPRESSION

SURVIVAL

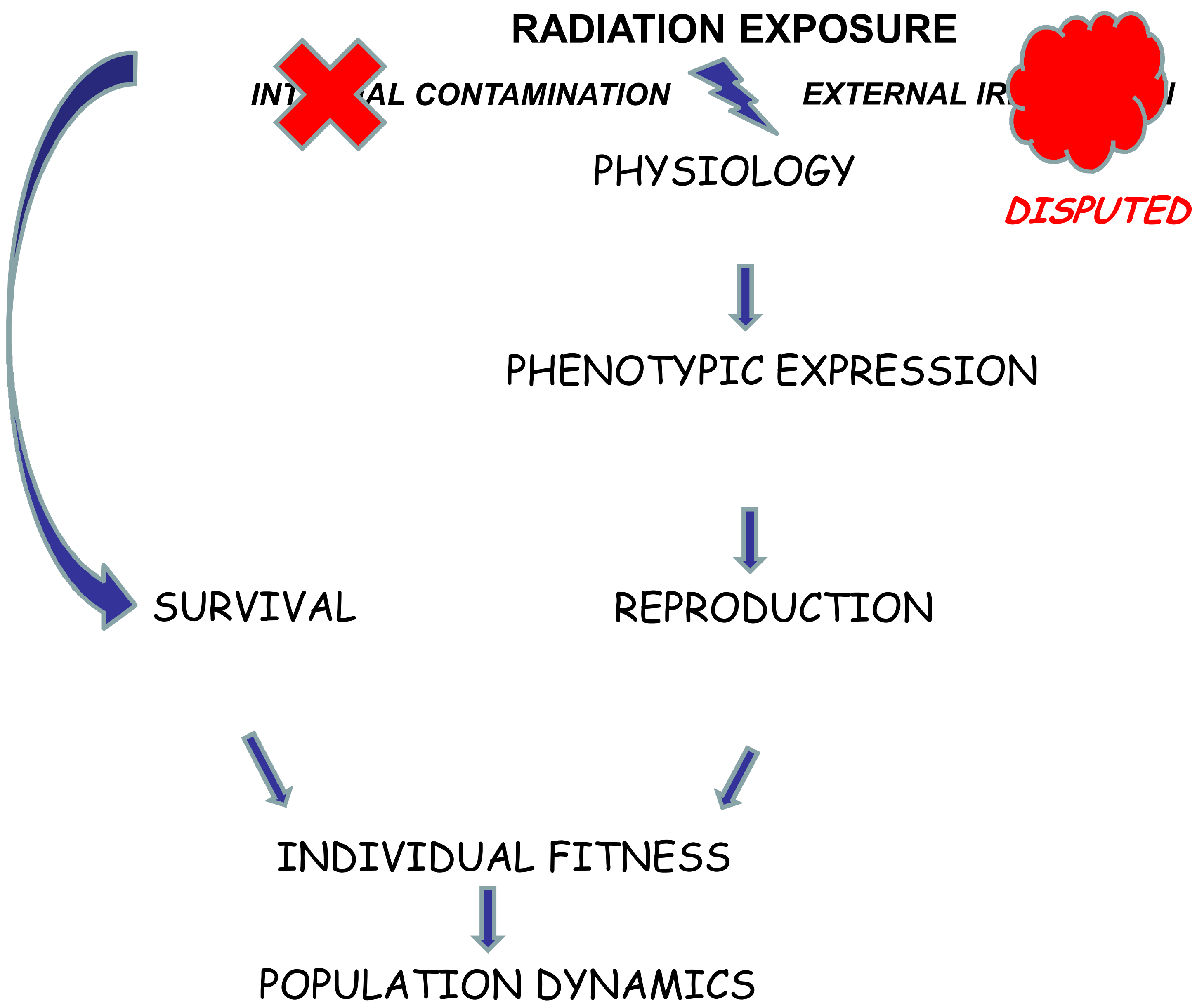
REPRODUCTION

INDIVIDUAL FITNESS

POPULATION DYNAMICS

Effects of ionizing radiation exposure on wild organisms

CHERNOBYL



Why the FREEBIRD project?

- From Chernobyl (26 April 1986)…to Fukushima (11 March 2011)

➡ To obtain short- & medium-term data set → **to assess short-term effects of ionizing radiations on wild individuals**

➡ To acquire accurate dosimetric measurements → **from the IRSN experience**

➡ To collect data on individual internal contamination → **to assess robust dose-response effects**

FREEBIRD project originality

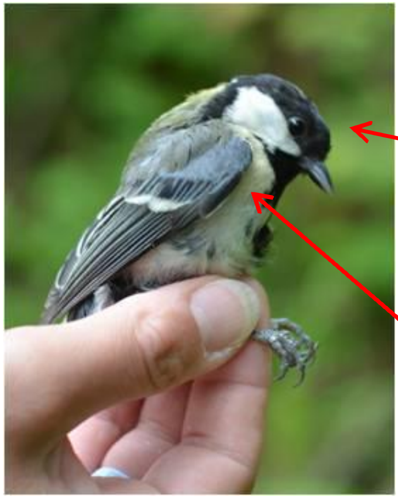
- Project originality → **integrative approach** based on **behavioural ecology** & **eco-physiology theories**, associated to **accurate dosimetric measurements**

➡ In behavioural ecology, animal "choice" process → based on **signals**

↳ Signal: **phenotypic trait** that informs about the **bearer quality**

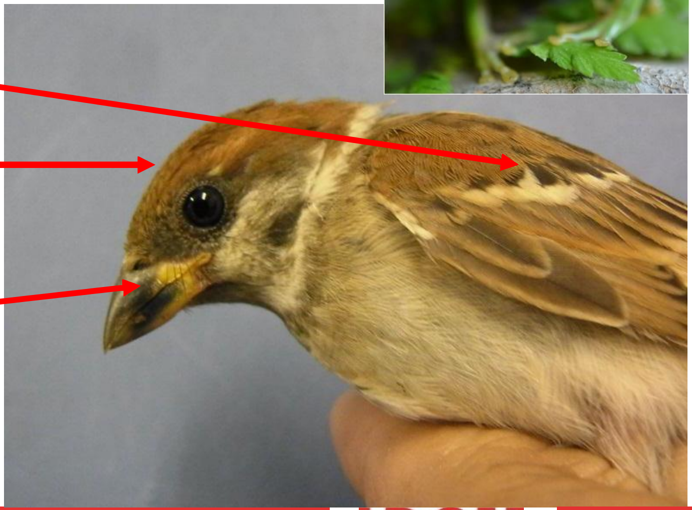
➡ In the wild, it exists ≠ **signal types**, among which the **most used** are **pigmentary visual signals** (i.e. **coloured traits**)

↳ Two **main pigment types**, with particular properties:



Melanin
- eu-melanin (grey to dark)
- Pheo-melanin (ruffus to brown)

Carotenoids (yellow to red)



Carotenoid pigments

- Carotenoids characteristics & properties:
  - **not synthetizable** by vertebrates
  - used in **different physiological functions**

FOOD
(i.e. environment)

↓ **Limiting resource**

CAROTENOIDS

Self-maintenance function		Communication function
↓	**Trade-offs** ⟷	↓
IMMUNO-ENHANCERS		COLORED TRAITS (indicative of individual quality, used during mate choice and/or parent-offspring communication)

Carotenoid-based traits might thus **reveal individual condition** and **quality**

Melanin pigments & Glutathione GSH

- Melanin characteristics & properties:
  - melanogenesis controled by available amount of GSH
  - **limiting resource** in the environment
  - used in **different physiological functions**

FOOD (i.e. environment)

↓ **Limiting resource**

Tyrosine

↓

MELANIN

GSH (gluthatione)

\+ → PHEO-MELANIN

− → EU-MELANIN

Self-maintenance function

↓

ANTI-OXIDANT

Trade-offs ⟷

Communication function

↓

COLOURED TRAITS (indicative of social ladder)

Melanin-based traits might thus reveal **individual quality** & **oxidative status**

Why the FREEBIRD project?

Aims of the FREEBIRD project

1) To define **key biological parameters** that can **inform**, in **real time**, about organism response to their **environment**

→ to assess whether coloured traits can be used as such

2) To determine external irradiation and internal contamination levels that can affect individual **physiology** and **health**

→ to obtain accurate dose-response curves at individual level

3) To identify **proximate physiological mechanisms** (physiological and/or genetic) leading to a possible **co-variation** between **individual coloured traits**, **external irradiation levels** and **internal contamination**

→ to predict potential long-term effects on population dynamics

General methodology

Study species

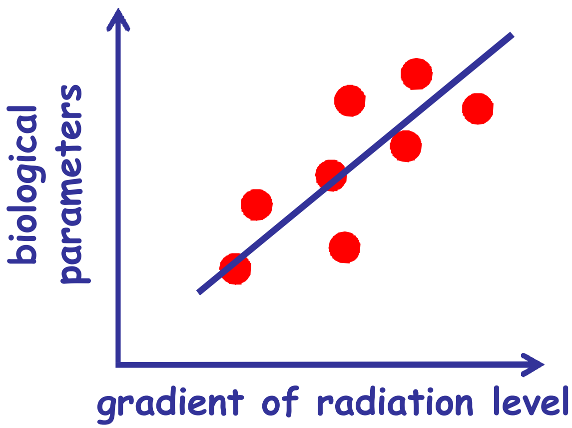
Trapping methods

Study sites

Characterisation of external irradiation level of study sites

Characterisation of individual contamination

Assessment of key biological parameters



Individual dose-response curves

RADIATION EXPOSURE

INTERNAL CONTAMINATION ***EXTERNAL IRRADIATION***

PHYSIOLOGY

PHENOTYPIC EXPRESSION

IONIZING RADIATION EFFECTS ON INDIVIDUAL FITNESS

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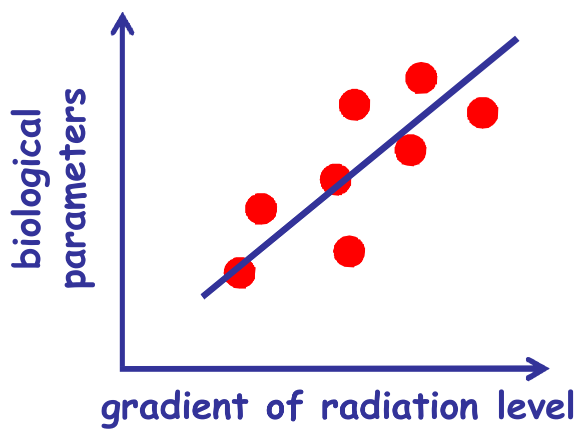

Individual dose-response curves

RADIATION EXPOSURE

INTERNAL CONTAMINATION

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Study species

- Bird species… and a frog species

➡ usually display **coloured traits** (i.e. carotenoid- and/or melanin-based)
➡ **easy to trap** and **handle**
➡ **common** and **distributed** along a **contamination gradient**
➡ widely studied at **Chernobyl** → **never studied**!!

Eurasian Tree sparrow
(*Passer montanus*)

Varied tit
(*Parus varius*)

Great tit
(*Parus major*)

Japanese tree frog
(Hyla japonica)

Trapping methods

- Mist-net catching & Nest-box use

Physiology

Phenotypic expression

+

Breeding performance

Trapping methods

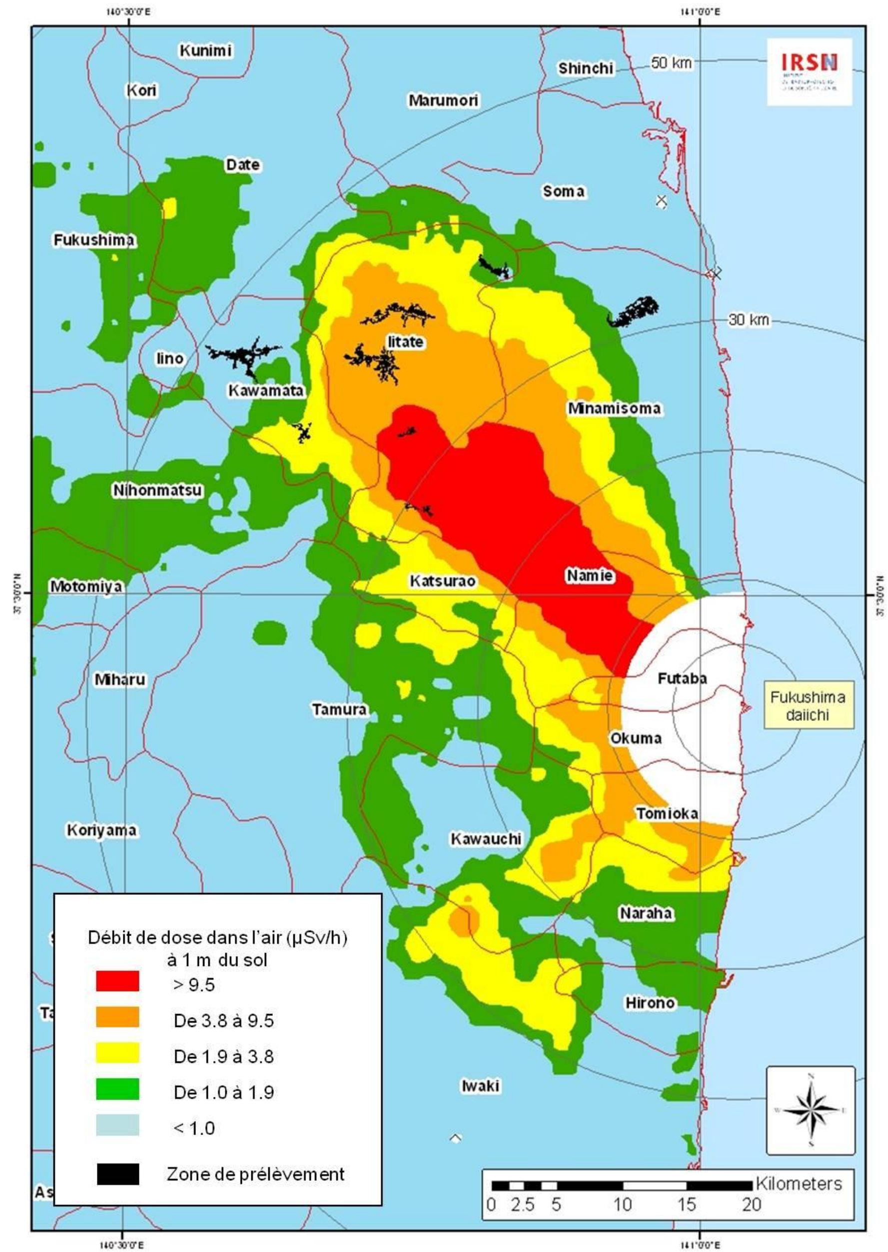
- Catching within rice field

Physiology

Phenotypic expression

Study sites

- External irradiation level gradient



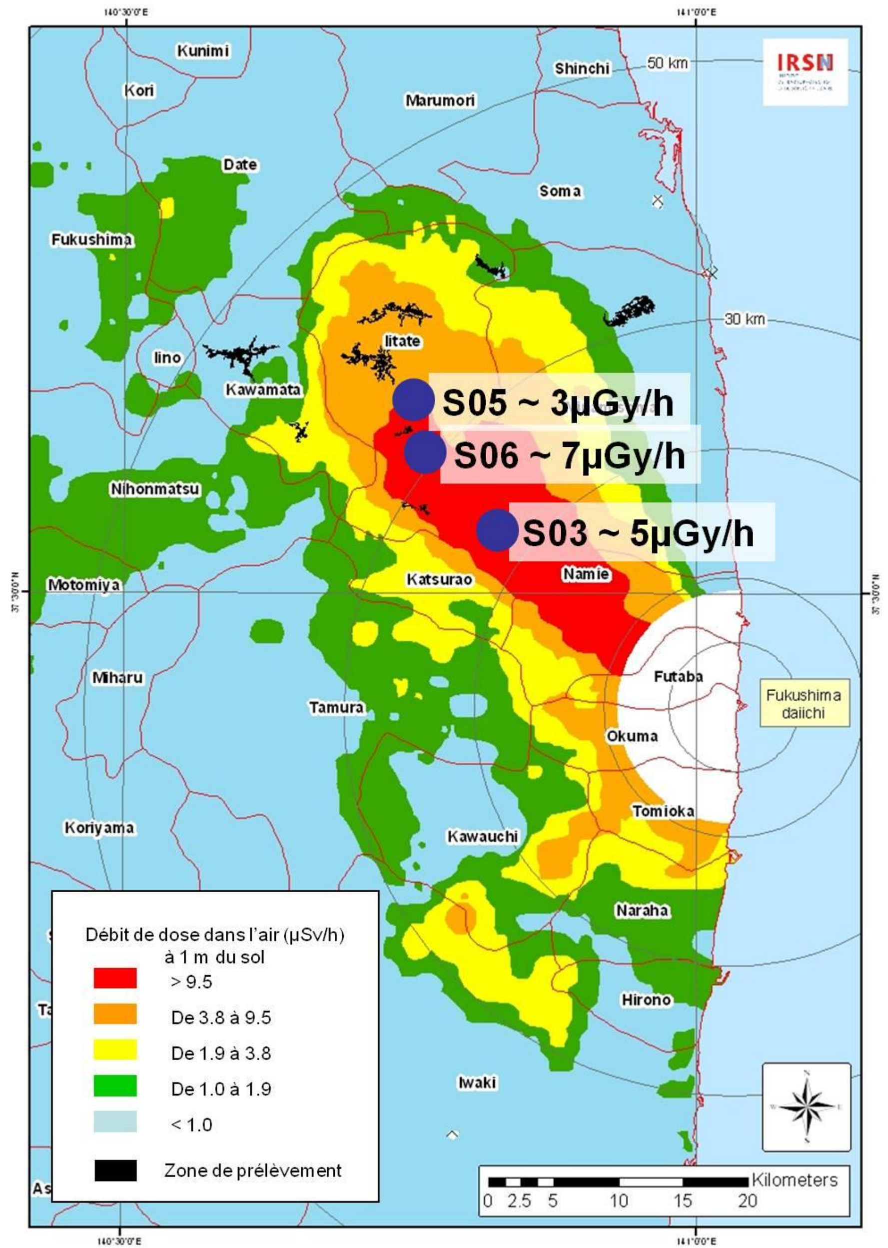
Carte établie par J.M. Métivier d'après le relevé aérien du 28 août 2011 effectué par le MEXT

Study sites

- External irradiation level gradient

➡ Tree sparrows

3 study sites (3 – 7 µGy/h)



Carte établie par J.M. Métivier d'après le relevé aérien du 28 août 2011 effectué par le MEXT

Methods & preliminary results

Study sites

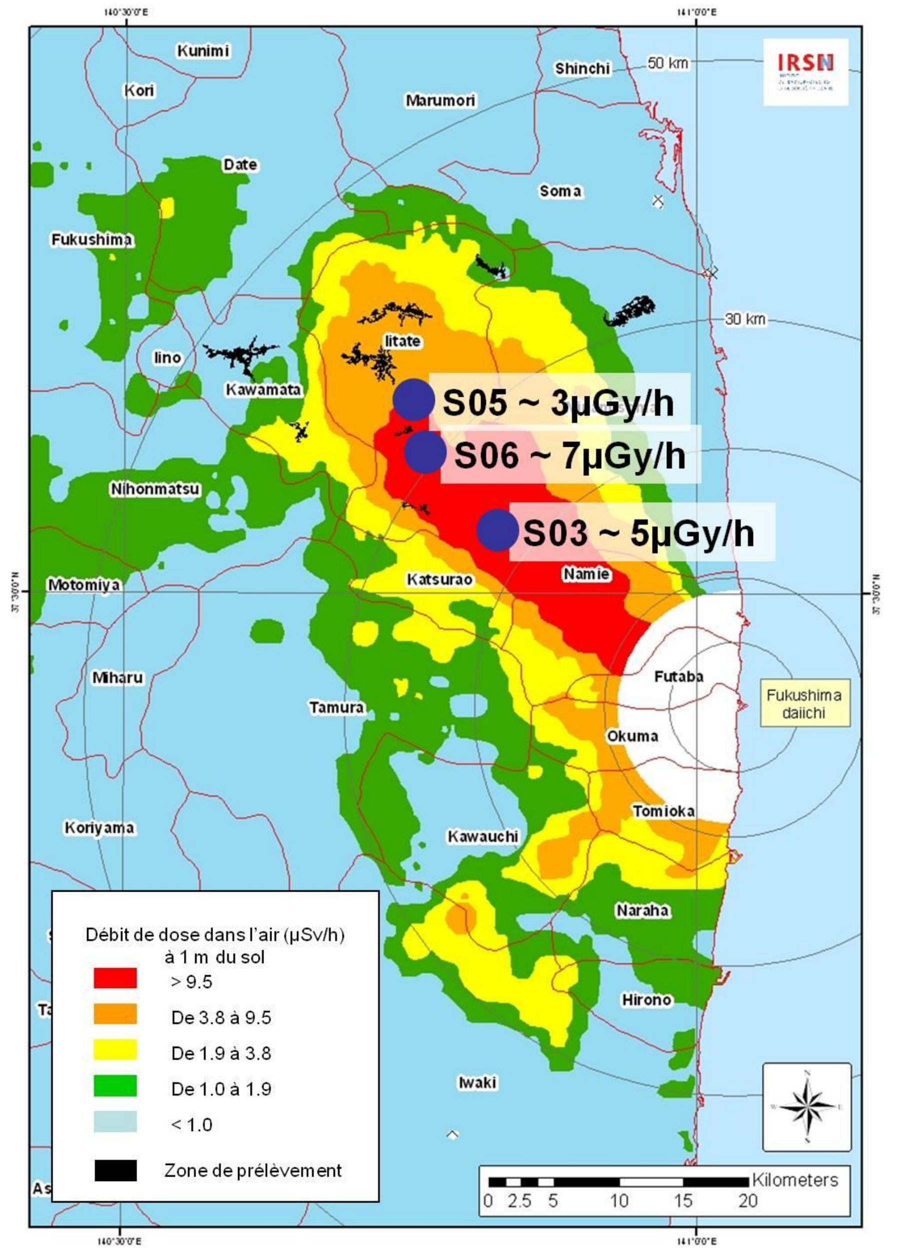
- External irradiation level gradient

→ Tree sparrows

↳ 3 study sites (3 – 7 µGy/h)

↳ homogenous

↳ Additional feeding



Carte établie par J.M. Métivier d'après le relevé aérien du 28 août 2011 effectué par le MEXT

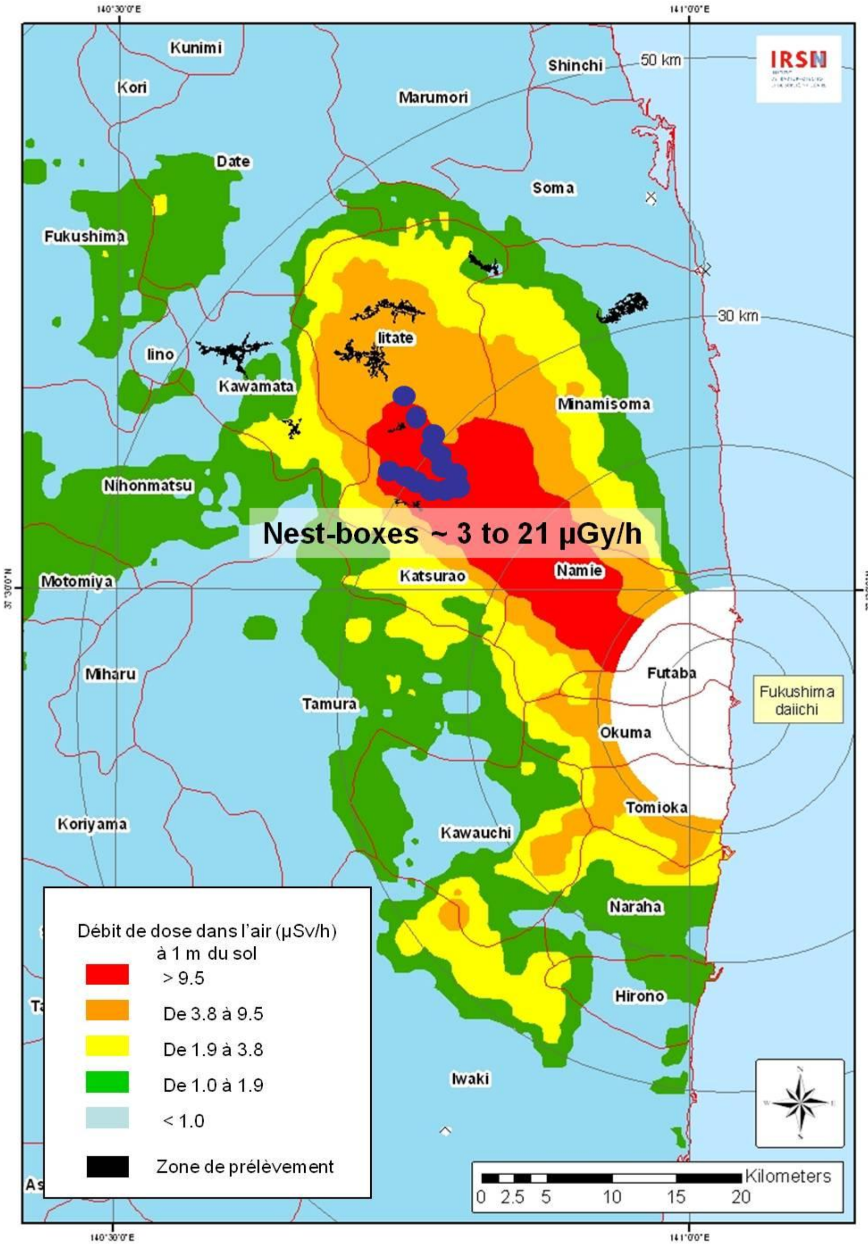
Study sites

- External irradiation level gradient

➡ Tit species

↪ 15 nest-boxes (3 – 21 µGy/h)

↪ homogenous



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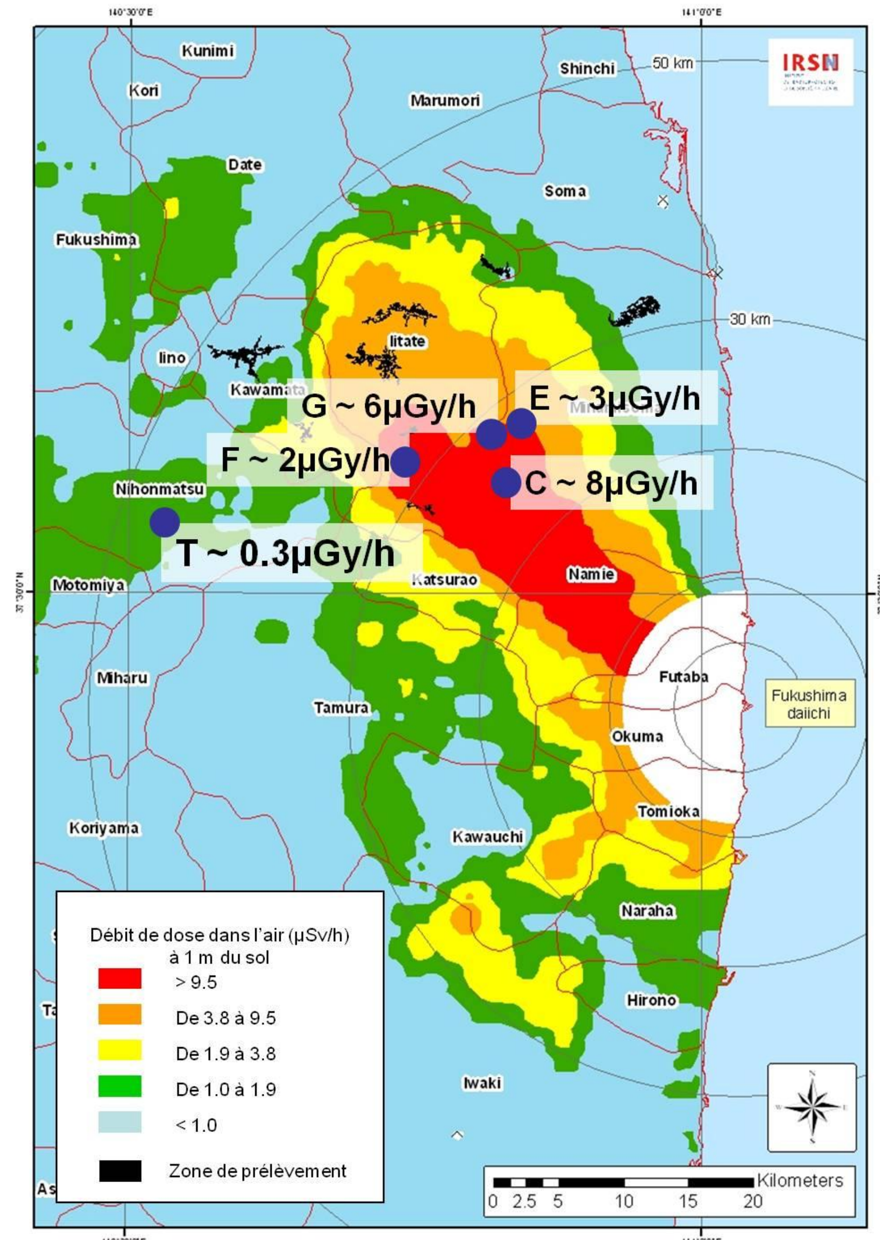
Study sites

- External irradiation level gradient

- Japanese tree frog
- 5 study sites (0.3 – 8 $\mu Gy/h$)
- homogenous



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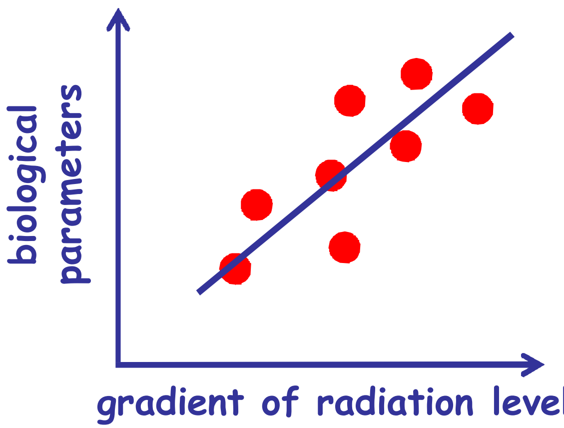
Assessment of key biological parameters



Individual dose-response curves

RADIATION EXPOSURE

INTERNAL CONTAMINATION

EXTERNAL IRRADIATION

PHYSIOLOGY

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IONIZING RADIATION EFFECTS ON INDIVIDUAL FITNESS

Characterisation of external irradiation level

- Dosimetry: external irradiation level

➡ Combination of **passive** & **active dose measurements**

dosimeters (RPL)

- integration time = 6 months
- 3 ≠ heights (10 cm / 1m / 2m)

Radiameter

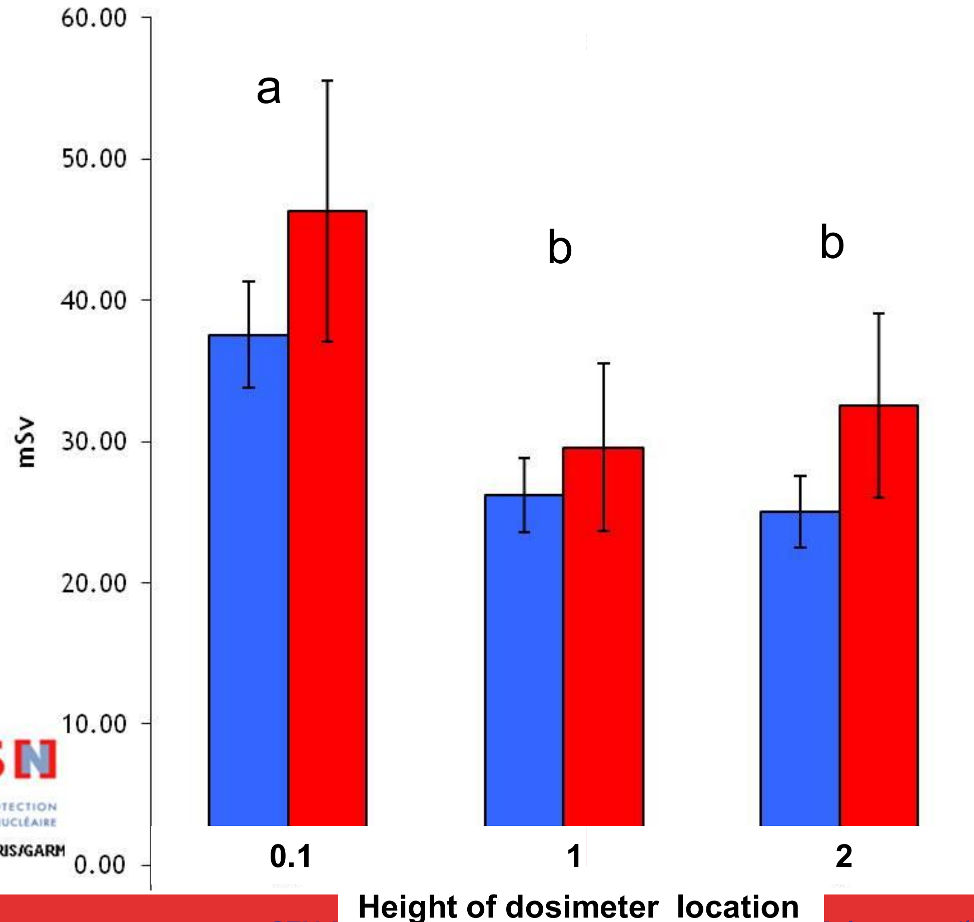
- integration time = real time output dose
- 3 ≠ heights (10 cm / 1m / 2m)

Characterisation of external irradiation level

Dosimetry: external irradiation level

➡ Ex: site S03

- Measurement type "Passive vs Active" effect: higher recorded radiation level with passive measurement;
- Location "10cm vs 1 & 2m" effect: higher recorded radiation level on the ground;



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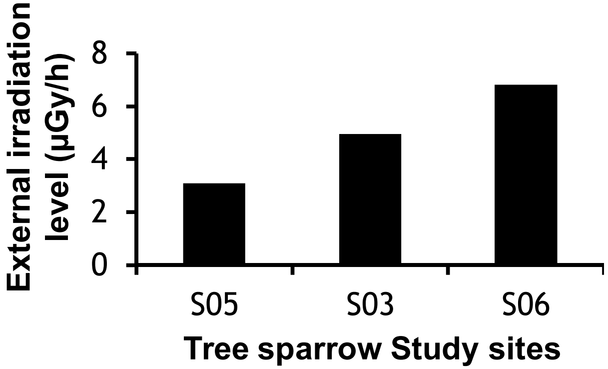
INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE
PRP-ENV/SERIS/GARM

Source
N. Dubourg

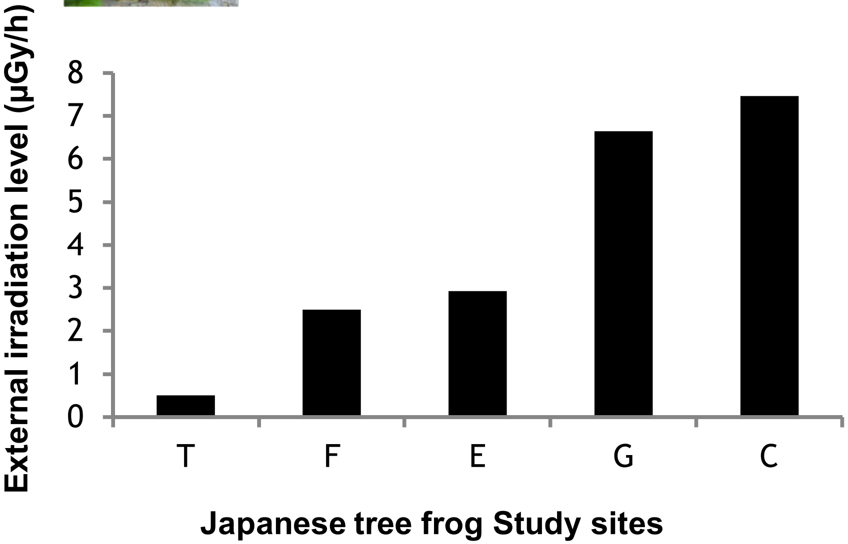
Characterisation of external irradiation level

Dosimetry: external irradiation level

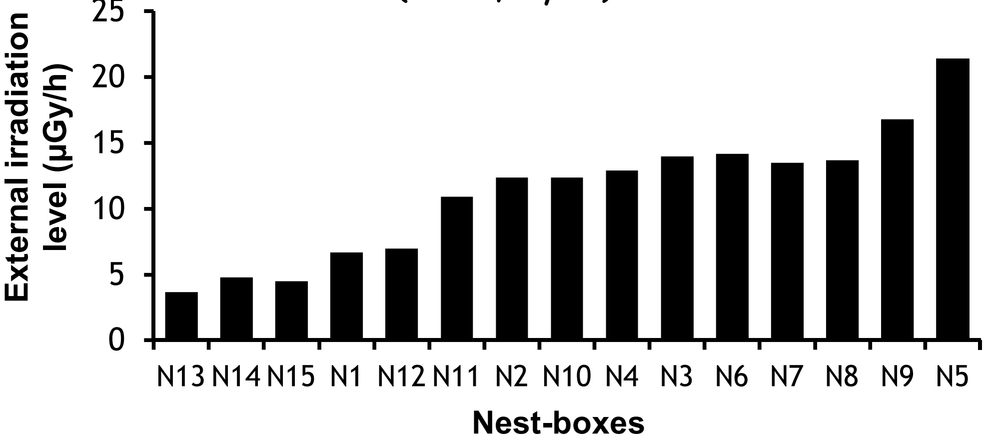
Tree sparrows
(3-7 μGy/h)



Japanese tree frog
(0.3-8 μGy/h)



Varied & Great tits
(3-21 μGy/h)



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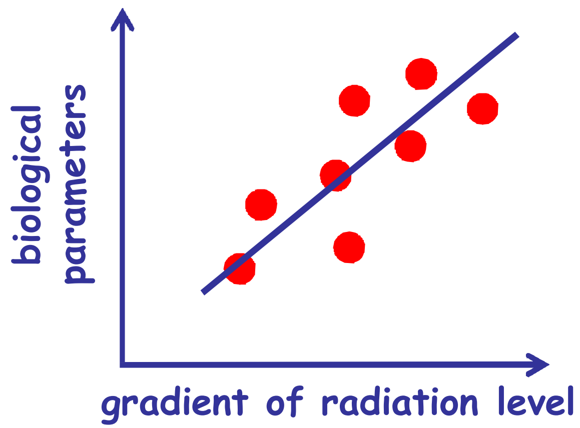


Individual dose-response curves

RADIATION EXPOSURE

INTERNAL CONTAMINATION — *EXTERNAL IRRADIATION*

PHYSIOLOGY

PHENOTYPIC EXPRESSION

IONIZING RADIATION EFFECTS ON INDIVIDUAL FITNESS

Characterisation of individual contamination

- Internal individual contamination
  - ➡ Method: in the field

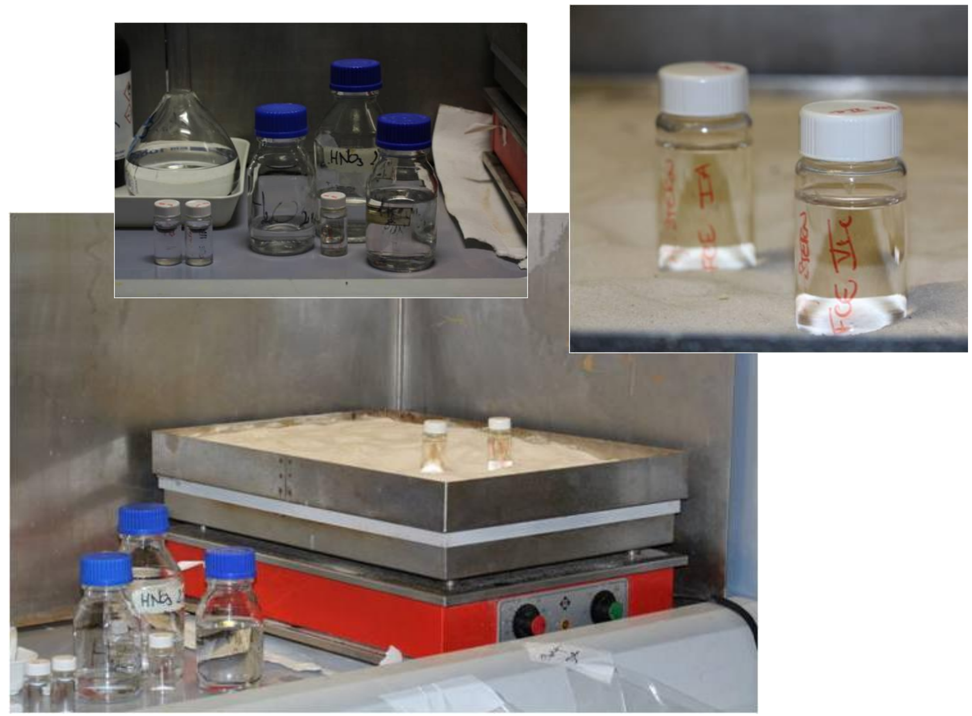
- Integration time = 600 sec → trade-off between measure accuracy & bird stress
- Background measurement and then individual measurement

Currently analysing

Characterisation of individual contamination

Internal individual contamination

➡ Method: in the field / in the lab

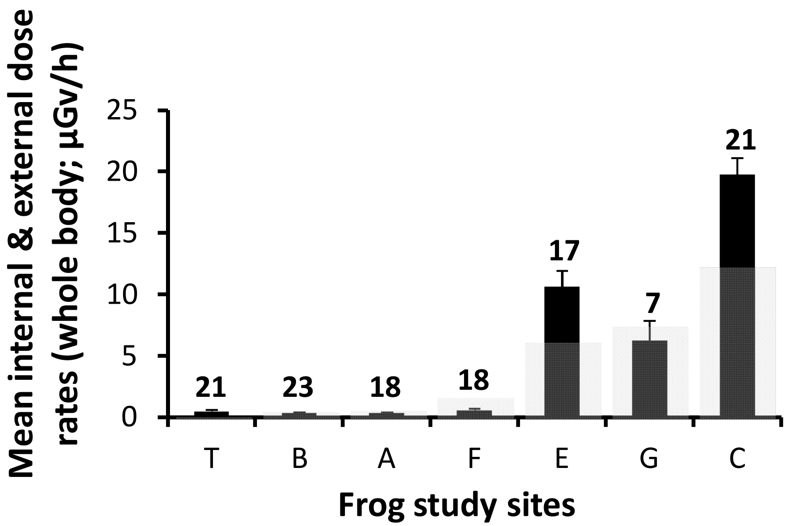


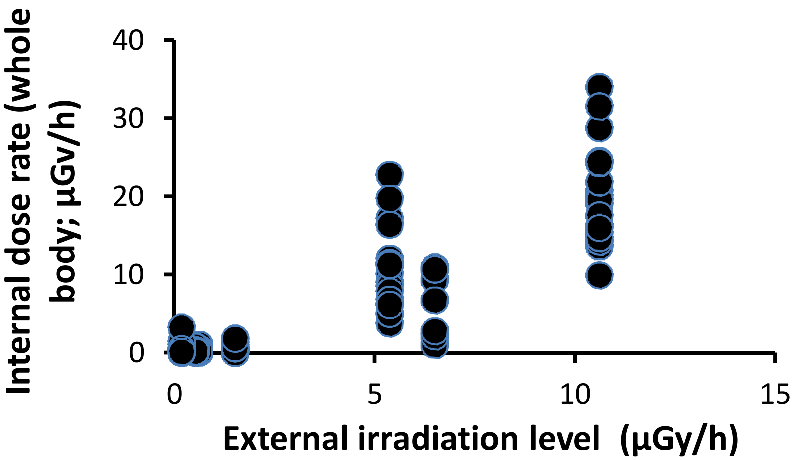
Individual capture in the field

Acid-wet digestion on dryied individuals → measurement of whole body contamination by spectrogamma technique (germanium detector)

Characterisation of individual contamination

Internal individual contamination





Site effect on individual whole body contamination:

GENMOD: $F_{6,118} = 178.19$, $p < 0.0001$

External irradiation level effect on individual whole body contamination:

GLIMMIX (random Study site): $F_{1,5.56} = 40.63$, $p = 0.0009$

Individual whole body contamination differs between study sites and increase with external irradiation level

General methodology

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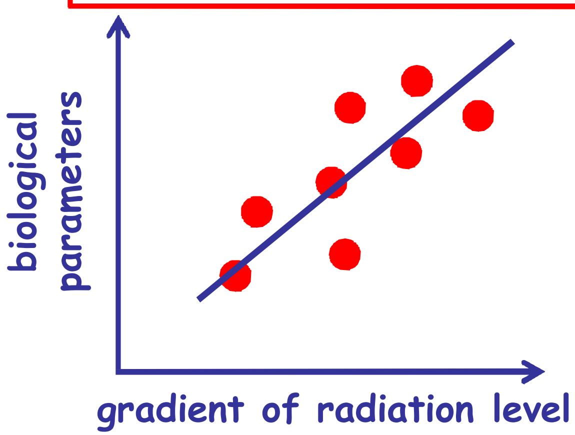

Individual dose-response curves

RADIATION EXPOSURE

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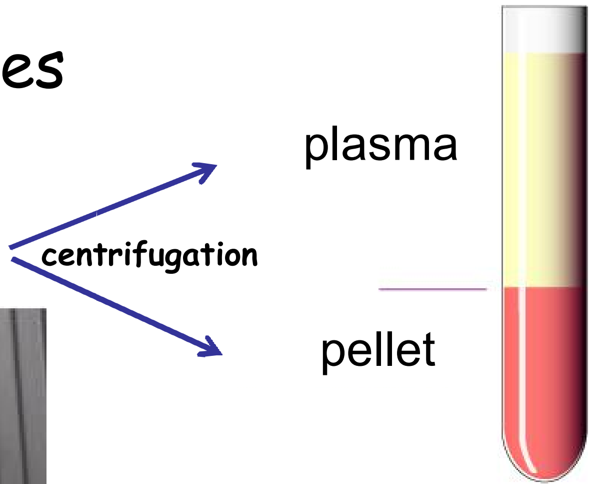
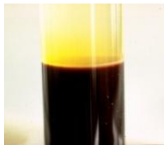
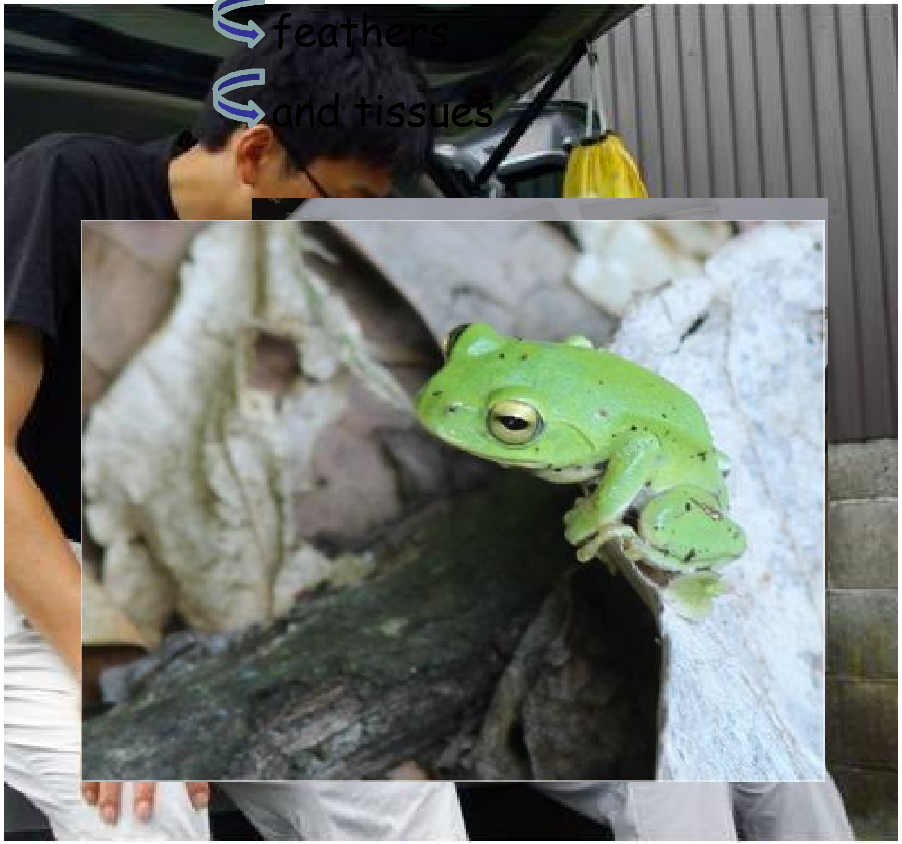
Key biological parameters

- Physiological parameters
  - Methods
    - from blood sample
    - feathers
    - and tissues







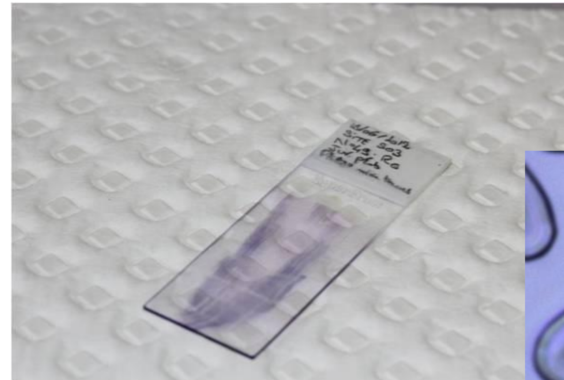
Key biological parameters

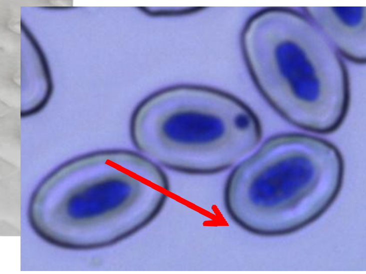


- Physiological parametres

Parametres	Variables
Colouration	Carotenoids Vit. A/E
Immune system	Blood smear test Plasmatic lysis capacity
Oxidative status	TBARS Oxide nitric Glutathione
Hormones	Testosterone Corticosterone

Key biological parameters





- ## Physiological parametres

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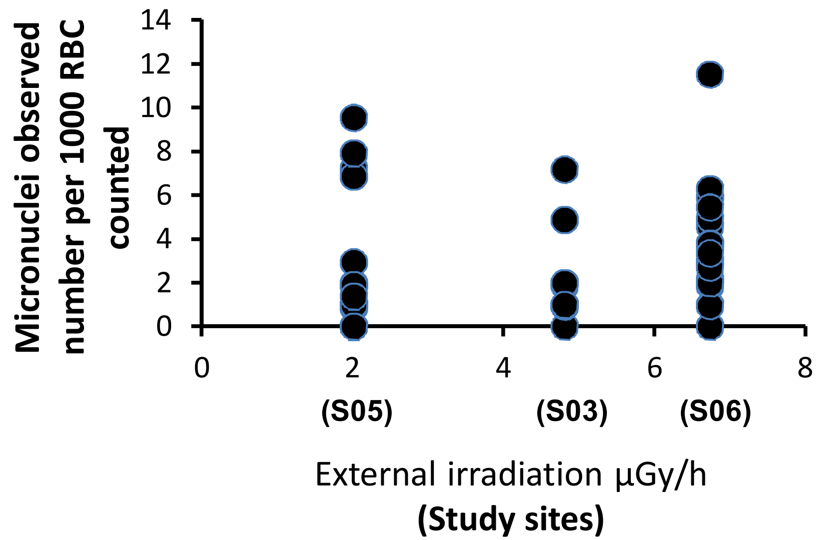


External irradiation (µGy/h) effects on number of micronuclei (per 1000 counted RBcells):

GENMOD (Distr. Poisson): $F_{2,61} = 2.69$, $p = 0.0757$

Key biological parameters

- Genetic parametres

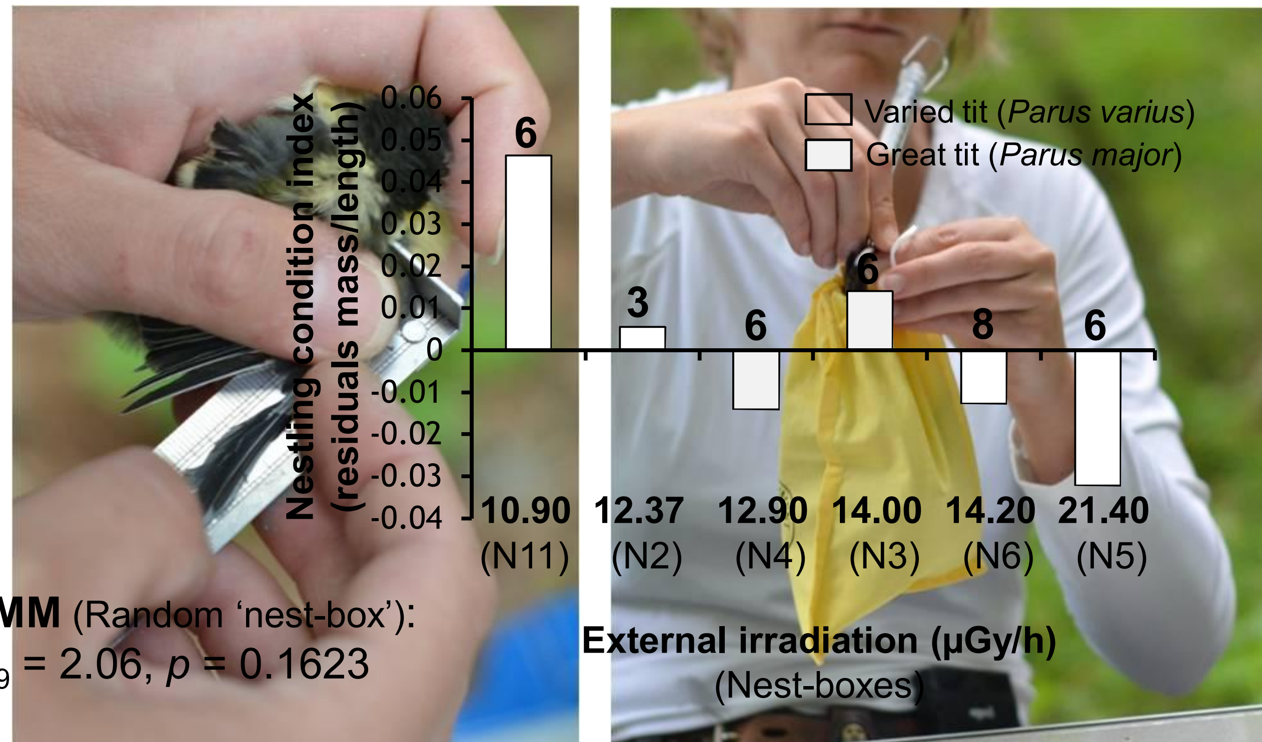
Parametres	Variables
DNA damage	Single strand DNA break
Epigenetic	DNA methylation
Gene expression	4 focus genes

Key biological parameters



Phenotypic expression

Parametres	Variables
Body condition	Biometric measures



GLMM (Random 'nest-box'):
$F_{1,29} = 2.06$, $p = 0.1623$

Key biological parameters



- Phenotypic expression

Parametres	Variables
Body condition	Biometric measures
Coloured traits (carotenoids / melanin)	Picture analyse Carotenoids in feathers & tissues

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