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Essay

Animal behaviour and cancer

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Scientists are increasingly coming to realize that oncogenic phenomena are both frequent and detrimental for animals, and must therefore be taken into account when studying the biology of wildlife species and ecosystem functioning. Here, we argue that several behaviours that are routine in an individual's life can be associated with cancer risks, or conversely prevent/cure malignancies and/or alleviate their detrimental consequences for fitness. Although such behaviours are theoretically expected to be targets for natural selection, little attention has been devoted to explore how they influence animal behaviour. This essay provides a summary of these issues as well as an overview of the possibilities offered by this research topic, including possible applications for cancer prevention and treatments in humans.

Apart from being a leading cause of human death worldwide, cancer is primarily a pathology of multicellular organisms that has appeared during the transition to metazoan life, approximately 1 billion years ago (Aktipis & Nesse, 2013; Nunney, 2013). It is observed in nearly the entire animal kingdom, from cnidarians to whales (see Table 1; Leroi, Koufopanou, & Burt, 2003). Yet, oncology, as a scientific field, has until now developed in relative isolation from evolutionary and ecological sciences. This is unfortunate because links between these disciplines have the mutual potential to reveal new perspectives and lines of research. For instance, while cancer is traditionally considered as a distinct pathology from a medical point of view, interdisciplinary approaches reveal that it is instead an unavoidable phenomenon governed by evolutionary principles and ecological relationships (Alfarouk, Ibrahim, Gatenby, & Brown, 2013; Casás-Selves & DeGregori, 2011; Daoust, Fahrig, Martin, & Thomas, 2013; Greaves, 2007; Merlo, Pepper, Reid, & Maley, 2006; Pepper, Scott Findlay, Kassen, Spencer, & Maley, 2009; Thomas et al., 2013). This is not a semantic problem, but rather a fundamental necessity to transform our understanding of cancer, its origin, the possible ways to control neoplastic progression and, probably most importantly, to prevent therapeutic failures (Aktipis & Nesse, 2013; Thomas et al., 2013). Similarly, although ecologists have ignored oncogenic phenomena, their roles in ecosystem functioning could in fact be important as

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Table 1
Examples of cancers observed in different metazoan groups and their known impacts on affected individuals

Group	Species		Context	Prevalence	Cancer	Factors favouring cancer	Impact	Source
	Common name	Latin name						
Invertebrates	Nonexistent	*Pelmatohydra robusta*	Laboratory population	Unknown	Undetermined	Genetic predisposition	Reduced population growth rate, reduced capacity of egg production	Domazet-Lošo et al., 2014
	Blue mussel	*Mytilus trossulus*	Cultured population	Up to 40% in northeast Pacific	Haemic neoplasia	Unknown	Increased mortality	C. M. Ciocan, Moore, & Rotchell, 2006; C. Ciocan & Sunila, 2005
	Drosophila	*Drosophila melanogaster*	Laboratory population (Oregon-R strain)	19% in 5 weeks old males	Gut and testis tumours	Unknown	Unknown	Salomon & Jackson, 2008
Fishes	Thornback skate	*Raja clavata*	Free-living	Unknown	Various forms, mainly affecting the skin	Unknown	Unknown	Ostrander, Cheng, Wolf, & Wolfe, 2004
	Coral trout	*Plectropomus leopardus*	Free-living	15% in part of the Great Barrier Reef	Melanomas	Genetic predisposition potentially associated with hybridization with another *Plectropomus* species.	Unknown	Sweet et al., 2012
	Brown bullhead	*Ameiurus nebulosus*	Free-living	Up to 68% in polluted North American rivers	Liver and skin tumours	Pollution (high concentrations of polynuclear aromatic hydrocarbons)	Damaged barbels	Baumann, Smith, & Parland, 1987; Pinkney, Harshbarger, May, & Melancon, 2001
Amphibians	Northern leopard frog	*Rana pipiens*	Free-living	Up to 6% in Minnesota populations studied between 1966 and 1977	Renal adenocarcinoma	Herpes virus infection	Probably causes death when metastasis occurs	McKinnell & Carlson, 1997; McKinnell, Gorham, Martin, & Schaad, 1979
	African clawed frog	*Xenopus laevis*	Laboratory population	5% in the studied population	Various forms the most common being hepatomas	Unknown	In some cases diseased individuals stop feeding and die	Balls, 1962; Goyos & Robert, 2009
	Montseny brook newt	*Calotriton arnoldi*	Free-living	Up to 27% in the remaining populations of Catalonia	Skin tumours	Potential role of UV-B radiations and elevated temperature to be confirmed	Unknown	Martínez-Silvestre, Amat, Bargalló, & Carranza, 2011
Reptiles	Green turtle	*Chelonia mydas*	Free-living	Up to 58% in the Hawaiian archipelago	Tumours of the skin, flippers, periocular tissues, carapace and plastron; nodules can also be found in all internal organs	Herpes virus infection	High mortality rates, impaired movements. Tumour-bearing turtles have a higher frequency of longer submergence intervals at night	Brill et al., 1995; Chaloupka, Balazs, & Work, 2009
	Egyptian mastigure	*Uromastyx aegyptius*	Captive (zoo)	53% in the studied population	Multicentric lymphomas	Unknown	High mortality rate	Gyimesi et al., 2005
	Corn snake	*Pantherophis guttatus*	Captive (zoo)	12% in the studied snake population including 5 cases in corn snakes (the total number of corn snakes kept in the zoo is not indicated)	Neoplasms of the lymphoid and haematopoietic tissues are the most common	Unknown	Unknown	Catao-Dias & Nichols, 1999
Birds	Red-tailed hawk	*Buteo jamaicensis*	Both free-living and captive individuals	Unknown	Various forms	Unknown	Probably caused death in some of the reported cases	Forbes, Cooper, & Higgins, 2000
	Rock dove	*Columba livia*	Laboratory population	34% in the studied population	Various forms, the three most frequent cancers are seminomas, thyroid adenomas and lymphomas	Unknown	Probably caused death and/or infertility in some of the reported cases	Shimonohara, Holland, Lin, & Wigle, 2012