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# Aromatic plants in bird nests as a protection against blood-sucking flying insects?

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## Abstract

The nest protection hypothesis suggests that some of the fresh plant material, brought by some bird species to their nests, contain secondary compounds that repel parasites or mask the chemical cues that parasites use to find the host. Corsican blue tits (*Parus caeruleus*) bring pieces of several species of aromatic plants to the nest at dusk, suggesting a protection against nocturnal agents such as blood-sucking flying insects. The potential repellent or masking effect of these aromatic plant species, alone or in mixture, was experimentally investigated in the mosquito *Culex pipiens*, using domestic chicks as bird hosts. Aromatic plants had a repellent effect against mosquitoes, although a masking effect could not be ruled out. The plant mixture was the most efficient, although some aromatic plants had a significant effect when used individually. These results are discussed in the context of the nest-protection hypothesis and of the impact of flying blood-sucking insects on bird behaviour and life history traits. © 2001 Elsevier Science B.V. All rights reserved.

**Keywords:** Aromatic herb; Nest protection; Mosquito; Parasite; *Parus caeruleus*

## 1. Introduction

Animals use different defence mechanisms against parasites such as complex immune systems, resistance genes or specific behaviours (Loye and Zuk, 1991; Clayton and Moore, 1997). One of these mechanisms is self-medication, i.e. a defence against parasites by using substances produced by other organisms (Clayton and Wolfe, 1993). In some bird species, individuals bring

green plant material to active nests that contain eggs or nestlings (Wimberger, 1984; Clark and Mason, 1985; Rodgers et al., 1988). Clark (1991) has reviewed the various functional hypotheses to explain this behaviour. The nest-protection hypothesis suggests that some of the fresh plants brought to the nest contain secondary compounds that repel parasites or mask the chemical cues that parasites use to find the host (Wimberger, 1984; Clark, 1991). This hypothesis provides the simplest explanation for why female Corsican blue tits (*Parus caeruleus ogliastreae*) incorporate into nests with eggs or nestlings, up to five aromatic

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herb species with distinct odours easily perceived by humans (Lambrechts and Dos Santos, 2000; Banbura et al., 1995). The plants selected represent a small fraction of the species observed in the blue tit territory. Furthermore, blue tits sometimes incorporate into the nest, fragments of plant species not observed in the territory (Lambrechts and Dos Santos, 2000; Petit, 2000). Lambrechts and Dos Santos (2000), therefore, hypothesised that a mixture of plants (the 'Potpourri effect') provides more benefits than the presence of a single plant species in the nest; for instance, treatment with a mixture of aromatic plant fragments would be a more efficient defence mechanism against parasites than the treatment with a single plant species (the 'Potpourri hypothesis').

Fresh plant material brought to the nest at the end of the evening, as observed in Corsican blue tits (Banbura et al., 1995), may be a defence mechanism against blood-feeding insects at night or dusk, such as ornithophilic mosquitoes (Rothschild and Clay, 1953; Jaenson, 1990). Although host–parasite interactions have been studied extensively in natural bird populations, the effects of blood-sucking flying insects on bird life history traits and behaviour are a neglected subject (Bucher, 1988; Loye and Carroll, 1995). This is probably explained by the relative discretion (nocturnal activity, ephemeral at the nest and small size) of these insects, which are essentially nematocera diptera: black flies (Simuliidae), biting midges (Ceratopogonidae) and mosquitoes (Culicidae) (Rothschild and Clay, 1953). However, the insects are probably detrimental to their host by removing some blood, although they also inject toxins and may act as vectors of parasitic diseases (Scott and Edman, 1991; Richner et al., 1995). Some studies indicate that these effects can dramatically affect some life history traits (Anderson et al., 1999), particularly when bites are numerous (e.g. Smith et al., 1998). In northern Europe, 20 species of mosquitoes have been found to feed preferentially or occasionally on birds (Jaenson, 1990), and some viruses such as the sindbis virus (Togaviridae: *Alphavirus*) or the Nile virus (Flaviviridae: *Flavivirus*) are equally found in birds and mosquitoes (Francy et al., 1989; Lundström et al., 1992; Anderson et al., 1999).

The aim of this study was to establish whether aromatic herb species found in Corsican blue tit nests repel blood-sucking flying insects or mask the presence of a host. Experiments were performed using the mosquito *Culex pipiens* (L.) (Diptera: Culicidae), which is common in Corsica (Raymond and Marquine, 1994) and can be a vector of avian malaria (Vinogradova, 2000). More specifically, experiments have been conducted with this mosquito presented to a bird host in laboratory conditions, with or without a mixture of the Corsican aromatic herb species. For practical reasons, domestic chicks (*Gallus gallus*) have been used in the experiments, instead of blue tits.

## 2. Material and methods

### 2.1. Plants

Four species of aromatic plants found in Corsican nests (Lambrechts and Dos Santos, 2000) were used: *Achillea ligustica*, *Helichrysum italicum*, *Lavandula stoechas* and *Cistus creticus*. For each experiment, 1 g of fresh material was used which is slightly above the mean, although within the range of natural variation of quantity (Lambrechts, unpublished data), containing either only one plant species or a mixture of all four, depending on the treatment: control (T1), mixture (T2); monospecific treatments: *A. ligustica* (T3), *H. italicum* (T4), *L. stoechas* (T5), or *C. creticus* (T6). A grass was used as control (1 g). All plants were transported from Corsica to the mainland and kept in greenhouses at the campus of the CEFÉ/CNRS, Montpellier.

### 2.2. Animals

Strains of the mosquito *C. pipiens* available in the Montpellier insectarium were used. When supply from the insectarium was insufficient, *C. pipiens* larvae and pupae were sampled from natural breeding sites near Montpellier. In all experiments, females were at least 10 days old, and were ready to be blood-fed. One strain of domestic chicks, 2–10 days old, weighing between 50 and

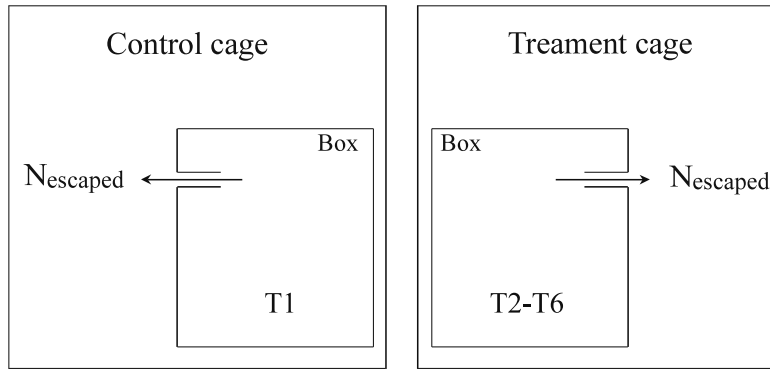


Fig. 1. Repellent experiment design. Mosquitoes are introduced in the boxes at the beginning of the experiment, and Nescaped represents the number of mosquitoes that escaped from the boxes at the end of the experiment. See text for details.

70 g, was used as the attractant and blood source. Chicks were kept (Université de Montpellier II, authorisation 005838) in the animal care facility of the University of Montpellier II. Whenever possible, each chick was used for only one experiment (a minimum of 50 chicks are housed in the care facility, and are renewed every other week). After each experiment, chicks were fed and allowed to rest before returning to the care facility.

### 2.3. Experimental design

Laboratory tests were conducted during June and July 1999.

#### 2.3.1. Repellent experiment

The potential repellent effect of aromatic herbs was tested using the apparatus presented in Fig. 1. For each experiment, at least 50 *C. pipiens* females were randomly distributed between two plastic boxes. One contained the control plant (T1) and the other one, a treatment plant (T2–T6). Each plastic box was located in a cage. Mosquitoes could escape from the boxes through four tubes (each ca. 8 cm<sup>2</sup>). After one night (about 14 h), mosquitoes remaining in each box, as well as mosquitoes that had escaped were counted. Each experiment was performed four times. Plastic boxes were cleaned with pentane before each experiment, in order to remove any previous odours (because pentane is a good solvent of volatile compounds). Experiments were performed for

each of the five treatments (T2–T6), giving a total of 20 assays.

#### 2.3.2. Choice experiment

Mosquitoes were presented in a choice experiment to two chicks, with or without aromatic herbs. Two plastic boxes containing chicks and either control (T1) or treatment (T2–T6) were placed in the same cage (see Fig. 2). There were  $n$  number of *C. pipiens* mosquitoes in the cage. Mosquitoes could enter boxes through four tubes (each ca. 8 cm<sup>2</sup>). After one night (about 14 h), the number of blood-fed females found in each box ( $n_1$  and  $n_2$ ) or in the cage ( $n - n_1 - n_2$ , i.e. those that escaped from one of the two compartments after blood feeding) were counted. As mentioned

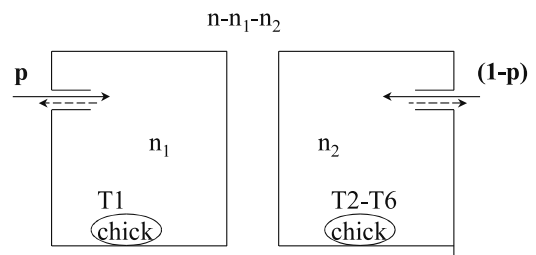


Fig. 2. Choice experiment design.  $n$  represents the number of female mosquitoes introduced in the cage at the beginning of the experiment.  $n_1$  (respectively,  $n_2$ ) Refers to the number of blood-fed females found in the control box (respectively, in the treatment box) at the end of the experiment.  $p$  indicates the probability for a blood-fed female to have bitten a chick of the control box. See text for details.

previously, each experiment was repeated four times for each treatment. Plastic boxes were cleaned with pentane before each experiment, in order to remove previous odours.

## 2.4. Statistics

### 2.4.1. Repellent experiment

The effect of aromatic herbs compared to the control plant was tested using a one-tail  $2 \times 2$  Fisher exact test for each experiment. The null hypothesis  $H_0$  was an absence of effect of the treatment. The alternative hypothesis was the repellent effect of the treatment. For each treatment, a global test was computed using Fisher's method (Manly, 1985).

### 2.4.2. Choice experiment

For each treatment, a blood-fed female has the probability  $p$  (respectively,  $1 - p$ ) of biting the chick in the control box (respectively, the treatment box). Because some mosquitoes escaped from plastic boxes after blood feeding, and therefore could not be assigned to a treatment, the effect of aromatic plants was tested using a conservative test. It was considered that blood-fed females which escaped, came only from the plastic box containing aromatic plants. For each experiment, data were analysed with an exact binomial test. The null hypothesis ( $p = 0.5$ ) was tested in presence of the alternative hypothesis:  $p > 0.5$ . For each treatment, the individual  $p$ -values associated with the four repetitions were combined (Fisher's method) to provide a global test. The minimum probability ( $p_{\min}$ ) of not rejecting the null hypothesis  $p = p_{\min}$  in presence of the alternative hypothesis  $p > p_{\min}$  was computed.

## 3. Results

### 3.1. Repellent experiment

Overall, the mixture of aromatic plants had a repellent effect ( $P < 0.01$ , Table 1). Individual plants had no repellent effect, with the exception of *L. stoechas* ( $P < 0.0001$ ). Results were heterogeneous for the mixture and *L. stoechas*, not all repetitions showing a repellent effect (Table 1).

### 3.2. Choice experiment

The mixture of aromatic herbs had a highly significant effect ( $P < 0.0001$ ) to protect chicks from female seeking a blood meal (Table 2). The corresponding minimal probability ( $p_{\min}$ ) of blood feeding in the control box was equal to or higher than 0.67 for three repetitions out of four. Two individual aromatic plants displayed a protective effect (*A. ligustica* and *L. stoechas*), despite the very conservative test used (if blood-fed females outside the boxes are ignored, all repetitions show a significant protective effect for *L. stoechas*, *H. italicum* and three out of four for *A. ligustica*).

## 4. Discussion

Many birds select fresh plant material that they bring to the nest (Wimberger, 1984; Clark and Mason, 1985; Rodgers et al., 1988; Milton and Dean, 1999). Several studies have investigated the potential anti-ectoparasite or anti-pathogen effect of these fresh plants (Clark and Mason, 1985, 1988; Hart, 1997), mainly because they have volatile compounds often considered to have possible repellent or toxic properties against insects, bacteria or herbivores (Jacobson, 1990; Barel et al., 1991; Rios et al., 1991; Afolayan and Meyer, 1997; Demetzos et al., 1997; Franzios et al., 1997; Adam et al., 1998). These studies have shown significant effects of these herbs against ectoparasites and microparasites like bacteria. Sometimes, no anti-ectoparasite property of the herbs was found, although a beneficial effect on survival was observed on nestlings (Gwinner et al., 2000). Corsican blue tits bring fresh plant material before dusk (Banbura et al., 1995), suggesting a nocturnal agent such as ceratopogonidae (e.g. genera *Culicoides*) or mosquitoes. *Culex pipiens*, the main vector of avian malaria and various viruses is regularly reported as a bird pest (Rothschild and Clay, 1953; Scott and Edman, 1991), including passerine (e.g. Niebylski and Meek, 1992). This mosquito is probably a serious bird pest in Corsica, although other mosquitoes of the genera *Aedes*, *Ochlerotatus* and *Culiseta* are probably

Table 1

Test of the repellent effect of aromatic herbs (four repetitions for each treatment), for the mixture of aromatic herbs and for each plant alone

Treatment type	Treatment cage (escaped/total)	Control cage (escaped/total)	P-value
Mixture	9/26	17/21	0.999
	12/22	7/27	<b>0.040</b>
	94/107	57/80	<b>0.004</b>
	16/74	14/91	0.203
Al:			<b>0.008</b>
<i>A. ligustica</i>	9/34	9/24	0.271
	5/36	19/39	0.999
	85/106	73/95	0.963
	64/103	108/150	0.271
Al:			0.776
<i>H. italicum</i>	11/41	17/35	0.986
	17/28	11/48	0.001
	18/54	19/45	0.868
	9/22	17/35	0.799
Al:			0.075
<i>L. stoechas</i>	34/48	29/46	0.280
	27/47	39/65	0.680
	61/76	15/29	<b>0.004</b>
	30/37	19/50	< <b>0.0001</b>
Al:			< <b>0.0001</b>
<i>C. creticus</i>	7/29	18/27	0.999
	7/28	6/24	0.627
	11/34	12/26	0.913
	5/39	5/45	0.536
Al:			0.938

The number of mosquitoes that escaped from each cage and the total number of mosquitoes introduced in each cage are indicated. 'Al' refers to a global test (Fischer's method). Bold characters indicate significant ( $P < 0.05$ ) values.

present in the forest occupied by *P. caeruleus* (Rioux, 1958; Rioux et al., 1974). Mosquitoes are regularly observed entering nest boxes in Corsica, although their species have not been identified (P. Perret, personal communication). In our laboratory study with aromatic herbs found in Corsican blue tit nests, the results of the repellent experiment show that there is a global repellent effect of the herbs on *C. pipiens*. In the choice experiment, control chicks were more often attacked than the chicks treated with some aromatic herbs, espe-

cially the mixture of plants. The first experiments indicate that aromatic plants repel mosquitoes, and the second indicate either a repellent effect or a more subtle phenomenon such as masking of the chemical cues used by mosquitoes to find hosts. The latter hypothesis may hold true because females of mosquitoes use olfactory receptors to locate plant and vertebrate hosts (Bowen, 1992; Takken and Knols, 1999). Using a combination of different volatile compounds is probably the most efficient way to create a chemical barrier

that masks hosts that are faced by several pest species (e.g. Wimberger, 1984; Lambrechts and Dos Santos, 2000). The plant mixture provided a greater protective value, although some individual plants have a significant effect alone (e.g. *L. stoechas*). Further experiments are required to gain more insight into the effect of these aromatic herbs.

Table 2  
Conservative test of the effect of aromatic herbs for each treatment

Treatment	$n_1$	$n_2$	$n$	$P$ -value	$p_{\min}$
Mixture	61	7	73	<0.0001	0.73
	33	11	56	0.114	0.47
	41	2	50	<0.0001	0.70
	138	18	188	<0.0001	0.67
All:				<0.0001	
<i>A. ligustica</i>					
	16	27	145	0.999	0.07
	21	4	142	0.999	0.10
	52	6	67	<0.0001	0.67
	26	12	53	0.608	0.37
All:				<0.001	
<i>H. italicum</i>					
	76	20	147	0.371	0.44
	92	7	157	0.019	0.51
	47	19	116	0.984	0.32
	16	2	93	0.999	0.11
All:				0.268	
<i>L. stoechas</i>					
	20	9	252	0.999	0.26
	33	0	97	0.999	0.26
	48	1	68	<0.0005	0.60
	35	5	53	0.014	0.53
All:				0.0023	
<i>C. creticus</i>					
	108	102	231	0.854	0.41
	155	20	293	0.175	0.47
	8	35	65	0.999	0.06
	34	14	70	0.640	0.38
All:				0.789	

$n_1$  (respectively,  $n_2$ ) Refers to the number of blood-fed females in the control box (respectively, in the treatment box) at the end of the experiment, and  $n$  indicates the total number of blood-fed females. Bold characters indicate significant ( $P < 0.05$ ) values. See text for details. The minimum probability ( $p_{\min}$ ) of choosing the control box explaining the data is indicated. See text for explanations.

Previous studies that have been concerned only with ectoparasites or bacteria could not consider the chemical host-masking hypothesis. Consequently, some authors may have simply rejected the nest-protection hypothesis because a repellent effect was not significant or because they do not take into account blood-sucking flying insects (e.g. Gwinner et al., 2000). Interestingly, the Corsican blue tits' nests with aromatic herbs can show high infestation rates of *Protocalliphora* flies, of which the blood-sucking larvae attack nestlings (Lambrechts, unpublished data). This suggests that the chemical barrier alone is not always efficient against all flying insects and seems not directed against *Protocalliphora*. In addition, volatile compounds may be less active during some periods of the day, making the chemical barriers less efficient at the time when some flying insects are active.

Due to the potentially large effect of parasitic flying insects on bird life history traits, it is not surprising to observe counter strategies (Hart, 1997). For example, in northern Europe, normal breeding of most migratory birds ends just before the first peak of massive mosquito emergence, which is perhaps not a mere coincidence (Dahl, 1973; Jonsson, 1994). Passerine nestlings are particularly easy targets to mosquitoes (absence of protective feathers) (Starck and Ricklefs, 1998). The present study indicates that the addition of green material to the nest could be a protective behaviour against mosquitoes and/or other blood-sucking diptera. Evidently, additional studies of host–flying insect interactions are required to test the nest-protection hypothesis in natural populations.

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## References

- Adam, K., Sivropoulou, A., Kokkini, S., Lanaras, T., 1998. Antifungal activities of *Origanum vulgare* subsp. *Hirtum*, *Mentha spicata*, *Lavandula angustifolia*, and *Salvia fruticosa* essential oils against human pathogenic fungi. *J. Agric. Food Chem.* 46, 1739–1745.
- Afolayan, A.J., Meyer, J.J.M., 1997. The antimicrobial activity of 3,5,7-trihydroxyflavone isolated from the shoots of *Helichrysum aureonitens*. *J. Ethnopharmacol.* 57, 177–181.
- Anderson, J.F., Andreadis, T.G., Vossbrinck, C.R., Tirrell, S., Wakem, E.M., French, R.A., Garmendia, A.E., Van Kruiningen, H.J., 1999. Isolation of West Nile virus from mosquitoes, crows, and a Cooper's hawk in Connecticut. *Science* 286, 2331–2333.
- Banbura, J., Blondel, J., de Wilde-Lambrechts, H., Perret, P., 1995. Why do female Blue Tits (*Parus caeruleus*) bring fresh plants to their nests? *J. Ornithol.* 136, 217–221.
- Barel, S., Segal, R., Yashphe, J., 1991. The antimicrobial activity of the essential oil from *Achillea fragrantissima*. *J. Ethnopharmacol.* 33, 187–191.
- Bowen, M.F., 1992. Terpene-sensitive receptors in female *Culex pipiens* mosquitoes: electrophysiology and behaviour. *J. Insect Physiol.* 38, 759–764.
- Bucher, E.H., 1988. Do birds use biological control against nest parasites? *Parasitol. Today* 4, 1–3.
- Clark, L., 1991. The nest protection hypothesis: the adaptive use of plant secondary compounds by European starlings. In: Loye, J.E., Zuk, M. (Eds.), *Bird-Parasite Interaction, Ecology, Evolution and Behaviour*. Oxford University Press, Oxford, pp. 204–221.
- Clark, L., Mason, J.R., 1985. Use of nest material as insecticidal and anti-pathogenic agents by the European starling. *Oecologia* 67, 169–176.
- Clark, L., Mason, J.R., 1988. Effect of biologically active plants used as nest material and the derived benefit to starling nestlings. *Oecologia* 77, 174–180.
- Clayton, D.H., Moore, J. (Eds.), 1997. *Host-Parasite Evolution. General Principles and Avian Models*. Oxford University Press, Oxford, p. 473.
- Clayton, D.H., Wolfe, N.D., 1993. The adaptive significance of self-medication. *Trends Ecol. Evol.* 8, 60–63.
- Dahl, C., 1973. Emergence and its diel periodicity in *Aedes (O.) communis* (DeG.), *punctor* (Kirby) and *hexodontus* Dyar in Swedish Lapland. *Aquilo Ser. Zool.* 14, 34–45.
- Demetzos, C., Katerinopoulos, H., Kouvarakis, A., Stratiagakis, N., Loukis, A., Ekonomakis, C., Spiliotis, V., Tsaknis, J., 1997. Composition and antimicrobial activity of the essential oil of *Cistus creticus* subsp. *eriophalus*. *Planta Med.* 63, 477–479.
- Francy, D.B., Jaenson, G.T., Lundström, J.O., Schildt, E.-B., Espmark, A., Henriksson, B., Niklasson, B., 1989. Ecologic studies of mosquitoes and birds as hosts of ockelbo virus in Sweden and isolation of inkoo and batai viruses from mosquitoes. *Am. J. Trop. Med. Hyg.* 41, 363–365.
- Franzios, G., Mirotsoy, M., Hatziaepostolou, E., Kral, J., Scouras, Z.G., Mavragani-Tsipidou, P., 1997. Insecticidal and genotoxic activities of mint essential oils. *J. Agric. Food Chem.* 45, 2690–2694.
- Gwinner, H., Oltrogge, M., Trost, L., Nienaber, U., 2000. Green plants in starling nests: effects on nestlings. *Anim. Behav.* 59, 301–309.
- Hart, B.L., 1997. Behavioural defence. In: Clayton, D.H., Moore, J. (Eds.), *Host-Parasite Evolution. General Principles and Avian Models*. Oxford University Press, Oxford, pp. 59–77.
- Jacobson, M., 1990. *Glossary of Plant-derived Insect Deterrents*. CRC Press, Boca Raton, p. 213.
- Jaenson, T.G.T., 1990. Vector roles of Fennoscandian mosquitoes attracted to mammals, birds and frogs. *Med. Vet. Entomol.* 4, 221–226.
- Jonsson, L., 1994. *Les oiseaux d'Europe, d'Afrique du Nord et du Moyen-Orient*. Nathan, Paris, p. 559 (in French).
- Lambrechts, M.M., Dos Santos, A., 2000. Aromatic herbs in Corsican blue tit nests: the 'Potpourri' hypothesis. *Acta Oecologia* 21, 175–178.
- Loye, J., Carroll, S., 1995. Birds, bugs and blood: avian parasitism and conservation. *Trends Ecol. Evol.* 10, 232–235.
- Loye, J.E., Zuk, M., (1991). *Bird-parasite interactions. Ecology, Evolution and Behaviour*. Oxford University Press, Oxford, pp. 406.
- Lundström, J.O., Turell, M.J., Niklasson, B., 1992. Antibodies to ockelbo virus in three orders of birds (Anseriformes, Galliformes and Passeriformes) in Sweden. *J. Wildl. Dis.* 28, 144–147.
- Manly, B.J.F., (1985). *The Statistics of Natural Selection on Animal Populations*. Chapman and Hall, London, p. 484.
- Milton, S., Dean, R., 1999. Nesting thyme. The use of aromatic plants in Cape Sparrow nests. *Africa—Birds and Birding*, February/March, 37–39.
- Niebylski, M.L., Meek, C.L., 1992. Blood-feeding of *Culex* mosquitoes in an urban environment. *J. Am. Mosq. Cont. Assoc.* 8, 173–176.
- Petit, C., 2000. *Diplôme d'études approfondies, Université de Montpellier II*.
- Raymond, M., Marquine, M., 1994. Evolution of insecticide resistance in *Culex pipiens* populations: the Corsican paradox. *J. Evol. Biol.* 7, 315–337.
- Richner, H., Christe, P., Oppliger, A., 1995. Parental investment affects prevalence of malaria. *Proc. Natl. Acad. Sci. USA* 92, 1192–1194.
- Rios, J.L., Recio, M.C., Villar, A., 1991. Isolation and identification of the antibacterial compounds from *Helichrysum stoechas*. *J. Ethnopharmacol.* 33, 51–55.
- Rioux, J.A., 1958. *Les Culicides du 'Midi' méditerranéen*. *Encyclopédie Entomologique* 35, 1–303.
- Rioux, J.A., Cousserans, J., Croset, H., Gabinaud, A., 1974. Présence du caractère autogène dans les populations d'*Aedes (O.) detritus* (Haliday, 1833) du 'Midi' méditerranéen et de la Corse. *Ann. Parasitol. Hum. Comp.* 49, 129–130.
- Rodgers, J.A. Jr., Wenner, A.S., Schwikert, S.T., 1988. The use and function of green nest material by wood storks. *Wilson Bull.* 100, 411–423.

- Rothschild, M., Clay, T., 1953. Fleas, flukes and cuckoos. Readers Union, Collins, London, p. 304.
- Scott, T.W., Edman, J.D., 1991. Effects of avian host age and arbovirus infection on mosquito attraction and blood-feeding success. In: Loye, J.E., Zuk, M. (Eds.), Bird-Parasite Interactions. Ecology, Evolution, and Behaviour. Oxford University Press, Oxford, pp. 179–204.
- Starck, J.M., Ricklefs, R.E., 1998. Patterns of development: the altricial-precocial spectrum. In: Starck, J.M., Ricklefs, R.E. (Eds.), Avian Growth and Development: Evolution within the Altricial-Precocial Spectrum. Oxford University Press, Oxford, pp. 3–30.
- Smith, R.N., Cain, S.L., Anderson, S.H., Dunk, J.R., Williams, E.S., 1998. Blackfly-induced mortality of nestling red-tailed hawks. *Auk* 115, 368–375.
- Takken, W., Knols, B.G.J., 1999. Odor-mediated behavior of afrotropical malaria mosquitoes. *Ann. Rev. Entomol.* 44, 131–157.
- Vinogradova, E.B., 2000. *Culex pipiens pipiens* Mosquitoes: Taxonomy, Distribution, Ecology, Physiology, Genetics, Applied Importance and Control. Pensoft Publishers, Moscow.
- Wimberger, P.H., 1984. The use of green material in bird nests to avoid ectoparasites. *Auk* 101, 615–618.