RAPTORS AND "CAMPO-CERRADO" BIRD MIXED FLOCK LED BY *Cypsnagra hirundinacea* (Emberizidae:Thraupinae).

RAGUSA-NETTO, J.

IB, UNESP, C.P. 199, CEP 13506-900, Rio Claro, SP, Brazil

Correspondence to: José Ragusa-Netto, Departamento de Ciências do Ambiente, CEUC, UFMS, C.P. 252, CEP 79304-020, Corumbá, MS, Brazil, e-mail: ragusa@pantanalnet.com.br

Received December 10, 1998 – Accepted July 29, 1999 – Distributed August 31, 2000

(With 1 figure)

ABSTRACT

Bird mixed flocks including *Cypsnagra hirundinacea* and *Neothraupis fasciata* as species with sentinels were studied in "campo-cerrado" in order to investigate the possible relationship between alertness and the mixed flock leadership. This study was conducted from March to September 1996 and mixed flocks were observed on average for 2:30h. The time with sentinels were recorded for *C. hirundinacea* and *N. fasciata*. The sentinels of *Cypsnagra hirundinacea* performed most of the vigilance (time with sentinel was on average 42 ± 17%, 41 ± 17% of which by *C. hirundinacea*, whereas only 1.2 % by *N. fasciata*) and gave all the alarm calls recorded (54% of the encounters with raptors stimulated alarm calls). A relationship was verified between time with sentinel and the rate of encounters with raptor (ANOVA, $F = 3.0$, $P < 0.05$). The results of this study are an evidence for the anti-predatory function of mixed flocks, in campo-cerrado, and the alertness as a major feature of a leader species, since *C. hirundinacea* always led those flocks.

Key words: mixed flock, sentinel, Thraupinae, raptors, nuclear species.

RESUMO

Predadores aéreos e bandos mistos de aves, em campo-cerrado, liderados por *Cypsnagra hirundinacea* (Emberizidae: Thraupinae).

Bandos mistos de aves incluindo *Cypsnagra hirundinacea* e *Neothraupis fasciata* como espécies que vigiam por sentinelas foram estudados em campo-cerrado de março a setembro de 1996. O propósito desse estudo foi verificar a possível relação entre o grau de alerta de uma espécie e a liderança dos bandos. Durante as observações (em média de 2h30) foi quantificado o tempo vigiado por sentinelas de ambas as espécies. Os sentinelas de *Cypsnagra hirundinacea* realizaram a quase totalidade da vigilância (tempo com sentinela foi em média de 42 ± 17% do tempo, sendo 41 ± 17% vigiado por *C. hirundinacea* e 1,2% por *N. fasciata*), além de emitirem todos os chamados de alarme registrados (54% dos encontros com predadores aéreos estimularam chamados de alarme). O tempo vigiado por sentinelas nos bandos apresentou relação significativa com a taxa de encontro entre os predadores aéreos e os bandos (ANOVA, $F = 3,0$; $p < 0,05$). Esses resultados evidenciam a função antipredatória dos bandos mistos em campo-cerrado e que o grau de alerta é uma característica relevante em uma espécie líder, uma vez que esses bandos sempre foram liderados por *C. hirundinacea*.

Palavras-chave: bandos mistos, Thraupinae, sentinelas, predadores aéreos, espécie nuclear.

INTRODUCTION

Bird mixed flocks are commonly found on a wide range of neotropical habitats, from tall rain forest to savannas (Munn & Terborgh, 1979; Alves & Cavalcanti, 1996). Among the hypotheses related to the advantages of this heterospecific social organization is the predator avoidance, due to the increased surveillance. Birds in flocks are better protected by their sum of vigilance effort (Pullian, 1973). As a consequense, individual effort is reduced and more time is available for activities such as food search (Metcalfe, 1984; Sullivan, 1984a; Beveridge & Deag, 1987; Hogstad, 1988; Popp, 1988; Carrascal & Moreno, 1992). Mixed flock formation and cohesion are dependent on bird responses to one another (Powell, 1985). In this respect, the role of nuclear species has been pointed out as remarkable to flock cohesion maintenance (Moynihan, 1962; Greig-Smith, 1978; Munn & Terborgh, 1979; Powell, 1979, 1985; Alves & Cavalcanti, 1996). Nuclear species is the one around which foraging activity is organized. In a quantitative sense, among the criteria used to identify them, is their propensity to be positioned in the front during flock's displacements (Rand, 1954; Greig-Smith, 1978; Powell, 1985). Several features of nuclear species are assumed as responsible for the attraction of attendant species (see Powell, 1985, and discussion in Huto, 1994). However, the alertness of nuclear species has been poorly stressed (but see Munn & Terborgh, 1979; Gaddis, 1980).

Alves & Cavalcanti (1996) studied mixed flocks in "cerrado" *sensu stricto* (Eiten, 1994) and found nuclear function in *Neothraupis fasciata*. Sentinels guarded groups of this species, wich was assumed as remarkable for the nuclear function, as the result of the protection provided by them.

In the "campo-cerrado" (a kind of Brazilian savanna more open than cerrado *sensu stricto*, Eiten (1994) mixed flocks may include *N. fasciata* and *Cypsnagra hirundinacea*. The latter is absent from closed cerrado (Ridgely & Tudor, 1994; Sick, 1997). These two species of tanagers are social and occurr in groups of two to six birds, or even more (Alves, 1990; Ridgely & Tudor, 1994; Ragusa-Netto, 1997a; Sick, 1997). Individuals of both species may be seen prominently perched, apparently watching about. Also, several species of raptors live in this site and have been seen threatening birds in mixed flocks with close low flight and attacks (Ragusa-Netto, 1999). In this respect one of the main functions of those flocks may be anti-predatory and the presumable surveillance performed by prominently perched birds is likely to play a significant role. In order to investigate the possible relationships between alertness and the *status* of leader (nuclear) species, I selected mixed flocks which included those two species of tanagers. Thus, in this study I verified: a) composition and size of mixed flocks including *C. hirundinacea* and *N. fasciata*, b) time with prominently perched birds, c) the possible function of prominently perched birds d) the leader species of flocks and e) the possible relationship between alertness and flock leadership.

STUDY SITE AND METHODS

I studied mixed flocks from March to September 1996 in a campo-cerrado in Brotas (São Paulo State, 22°11'S, 47°54'W, altitude 750 m). The site area is approximately 1,500 ha, and the vegetation consists of bushes and small trees (heights ± 1-6 m), interspersed with open grassy areas. Mean annual temperature is 19.7°C and mean annual rain fall around 1,430 mm. There is a wet-hot season extending from October to March and a dry-cold season from April to September, when temperature often drops to 2°C or even less and frosts may occur. As a result, a large number of trees and bushes simultaneously drop their leaves.

In order to find the birds I walked 11.5 km of trails in the campo-cerrado. Twelve points (1,000 m away from each other) were selected in the trails from where I started walking. Starting points and the direction to be followed were randomized by lot without replacement. Observations were developed from 07:00 to 11:30 h and from 13:00 to 17:30 h. Only one mixed flock was studied in each period. If the flocks were lost from view within 1 hr, the observation period was discarded. Observation periods were also discarded if the leader species started confrontations towards conspecifics before 1 h had passed. In that case, I abandoned the flock and tried to study another one. If confrontations started after 1 h, I interrupted the observation and took it as a replicate for

statistical analysis. This was done to assure the observation of only a flock per period. On average, 35 h were employed monthly in the attempt to study the mixed flocks. Birds were watched through 8 x 30 binoculars, and the observations were dictated into a portable recorder for later transcription. When an appropriate flock (including only *C. hirundinacea* and *N. fasciata* with presumable sentinels) was found, I waited 5-10 min to allow the birds to become habituated. After that, I registered: a) bird species, b) flock size, c) time with at least one prominently perched bird, d) raptors seen while flocks were observed and e) bird reaction to raptors. I almost continuously observed the prominetly perched birds to check if they were doing regular rotatory movements of the head holding the bill horizontally positioned, once the performance of those movements suggests the bird is vigilant.

Birds were assumed to be in a mixed flock if at least one species followed another one for more than five minutes. The semi-open vegetation made it possible to distinguish that one species started and conducted a flock displacement. Thus, in this study, the leader species was defined as the one followed by the others, during a period of observation. The leader species is thought of as nuclear because it was always joined and followed by other species (Moynihan, 1962; Munn & Terborgh, 1979; Powell, 1985). I distinguished contact calls and alarm calls through bird responses. Contact calls caused the cohesion of a group and were conspicuously given when a member from a group started a displacement. Alarm calls were identified by the instantaneous evasive response of birds. To normalize data for statistical analysis, percentages of time with birds prominently perched were transformed using the arcsine function. Statistical procedures followed Sokal & Rohlf (1981).

RESULTS

I studied 30 mixed flocks including *C. hirundinacea* and *N. fasciata*. Flocks were directly observed for a total of 72 h. Mean observational period per flock was 2:30 h. *C. hirundinacea* was always the species followed. The mixed flock often spent some time foraging at a given place. After that, a member of the group of *C. hirundinacea* started to give contact calls and displaced for 20-40 m. Fellow group members responded with the same calls and flew close to the leader. Soon after, the other species in the flock did the same. This pattern of displacement made it simple to identify the leader species.

Table 1 shows the species recorded in the mixed flocks, their frequency of occurrence and mean number of individuals per group. Most species are in the Emberizidae, and almost all were passerines, except for two woodpeckers (*Picoides mixtus* and *Veniliornis passerinus*). The mean (± s.d.) number of species per mixed flock was 5.5 ± 1.8 and the mean flock size was 14.4 ± 4.7 birds. The species number and flock size were significantly correlated ($r = 0.71$, $p < 0.05$, Pearson correlation). The group size of *C. hirundinacea* and *N. fasciata* was larger than most other species (Table 1).

The individuals of *C. hirundinacea* and *N. fasciata* observed prominently perched constantly turn their head, first to one side, then to the other, holding the bill horizontally positioned. Most importantly, those birds gave loud calls (alarm calls, see results bellow) to which all fellow group members and other bird species responded by escaping into cover. Birds of both species took turns to watch about; two or more prominently perched birds watching about were seldom present at the same time.

On average, at least one prominently perched bird was present 42 ± 17 % of the time (*C. hirundinacea* = 41 ± 17%; *N. fasciata* only 1.2%). Several species of raptors encountered with the mixed flocks. I observed that an approaching raptor regularly triggered alarm calls, which were always given by prominently perched birds of *C. hirundinacea* (54% of the encounters (N = 24) with raptors stimulated alarm calls, Table 2). Encounters between raptors and mixed flocks varied from distant to close low flight. Apparently, the threatening degree was related to variables such as raptor species, distance between raptors and flocks, encounter patterns of each species of raptor, among others. As there was not a specific and uniform pattern of encounters between raptors and mixed flocks, all kinds of encounters were grouped in classes according to raptor encounter per hour, for the statistical analysis.

The rate of encounters between raptors and flocks was significantly related to time with prominently perched birds (ANOVA, $F = 3.0$, $p < 0.05$, Fig. 1).

TABLE 1

Species recorded, their frequency of occurrence and mean (± s.d.) group size, in mixed flocks (N = 30) including *Cypsnagra hirundinacea* and *Neothraupis fasciata*.

Species	% Occurrence	Mean group size
Cypsnagra hirundinacea	100	4.8 ± 1.5
Neothraupis fasciata	100	3.6 ± 0.9
Emberizoides herbicola	97	2.3 ± 1.4
Melanopareia torquata	70	1.0 ± 0.2
Synallaxis albescens	60	1.4 ± 0.5
Ammodramus humeralis	53	1.1 ± 0.3
Zonotrichia capensis	20	2.2 ± 1.5
Suiriri suiriri	13	1.3 ± 0.5
Picoides mixtus	10	1.6 ± 0.6
Comptostoma obsoletum	7	1.0
Sporophila plumbea	7	2.0
Alectrurus tricolor	3	3.0
Veniliornis passerinus	3	1.0
Volatinia jacarina	3	8.0

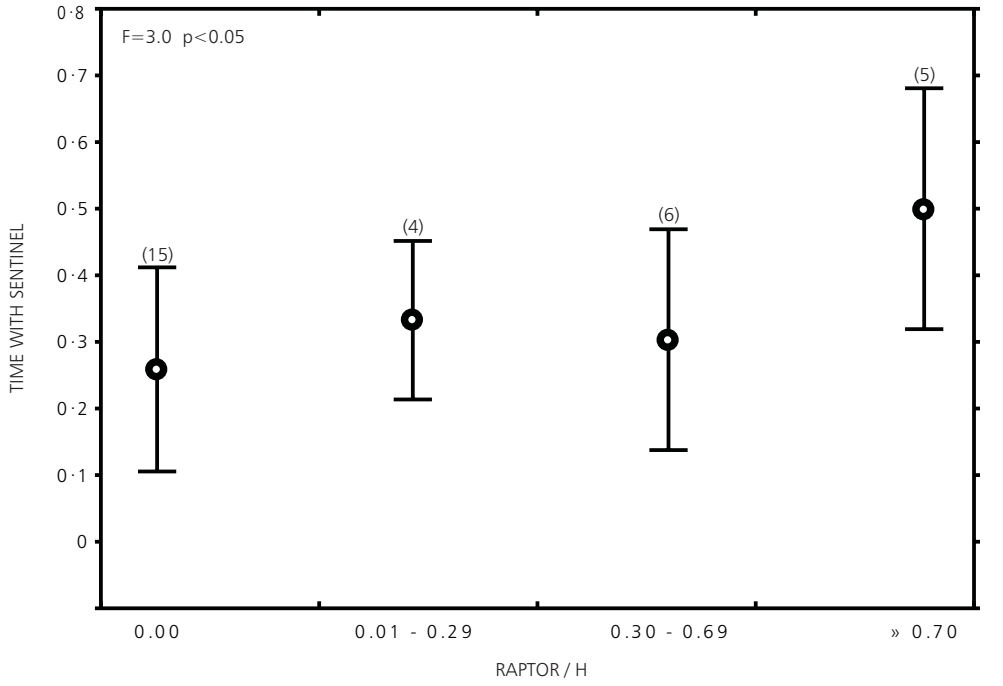

Fig. 1 — Raptor encounter rate with mixed flocks (in classes) and mean (± s.d.) time with prominently perched birds. Sample size above each mean, F value and probability are also given.

TABLE 2

Species of raptors recorded as a potential threatening to mixed flocks, their frequencies of encounters (N = 24) with mixed flocks and alarm call stimulated (N = 13).

Species	% of encounters	% alarm calls
Falco femoralis	21	43
F. sparverius	17	7
Buteo albicaudatus	25	29
B. magnirostris	12	7
Milvago chimachima	12	–
Elanus leucurus	8	–
Rhinoptynx clamator	4	7

DISCUSSION

Sentinels have been reported in some species of group living birds (Andrews & Naik, 1970; Gaston, 1977; Wickler, 1985; Verbeek & Butler, 1981; Ferguson, 1987; McGowan & Woolfenden, 1989). While prominently perched, they can earlier detect predators and alert those being protected, which are commonly busy in foraging activities. In this way, the increased perception of sentinels may substantially lower the risk of predation (McGowan & Woolfenden, 1989). In this study, prominently perched birds watching about earlier gave all alarm calls recorded in the presence of raptors, warning foraging birds. This pattern of responses suggests sentinel function to prominently perched birds. In the studied mixed flocks, this duty was largely performed by *C. hirundinacea*, the species which was always followed by the others.

The campo-cerrado is a semi-open habitat where birds are vulnerable while foraging, mainly on the ground or close to it (Lendrem, 1983). In the study site, birds prominently perched, presumably watching for predators have been observed in other species such as *Saltator atricollis*, *Mimus saturninus* and *Cyanocorax cristatellus* (pers. obs.). In the same area, I observed many attacks of raptors (*Falco femoralis* and *F. sparverius*) to mixed flocks. Successful attacks were avoided due to alarm calls given by prominently perched birds ("sentinels"), which instantaneously drew all birds to inside cover (Ragusa-Netto, 1999). The possible occurrence of sentinel behavior in several campo-cerrado bird species, together with a high raptor threatening degree, stressed the alertness as an anti-predatory device. An evidence of the implications of this adaptations is that several less alert bird species always closely followed the ones guarded by sentinels and never the other way round (Ragusa-Netto, 1999, this study).

Nuclear species features such as high sociability, regularity of contact calls and active movements, besides a front position during flock displacements, fit to *C. hirundinacea*. Furthermore and most importantly, this species revealed high alertness. Munn & Terborgh (1979) reported sentinel species (*Thamnomanes*) in Amazonian mixed flocks, classifying them as nuclear. The authors emphasized that their alarm calls benefited all the birds in the flocks. Gaddis (1980) pointed out that the complex of anti-predatory adaptations of a species play a major role in the attraction of others to the flocks. Thus, the *status* of nuclear species is intimately tied to the alertness. Sullivan (1984a) showed benefits for attendant species in mixed flock due to the exploitation of the nuclear species alertness. The attendant species increased foraging efficiency as a consequence of the decreased time for scanning. Ragusa-Netto (1997b) found evidence for foraging benefits to *Furnarius rufus* in the presence of *Mimus saturninus*, a highly social and alert species. The alertness in *M. saturninus* was suggested as the main characteristic attracting *F. rufus* to foraging close to them. Alves & Cavalcanti (1996) found evidences for benefits to *N. fasciata*, the nuclear species in the cerrado flocks. Sentinels of this species were present for less time, in mixed flocks than in conspecific groups, presumably as the result of better protection provided for the flocks.

In this study, time with sentinel was related to the rate of encounters between raptors and mixed flocks. Apparently, mixed flocks were better guarded as the threatening level increased. This result resembled the seasonal pattern of sentinel performance verified for *Aphelocoma coerulescens*, parallel to the seasonal abundance of raptors (McGowan & Woolfenden, 1989). Also, in some studies a relationship was verified between time employed to scanning and the risk of predation (Lazarus, 1979; Caraco *et al.*, 1980; Hegner, 1985).

In the studied mixed flocks, evidence also emerged for benefits to the species by exploiting each other's vigilance. The vigilance done by sentinels of *N. fasciata*, for example, was extremely low, while in the presence of *C. hirundinacea*. In the mixed flocks studied in the cerrado (Alves & Cavalcanti, 1996), where *C. hirundinacea* was absent, the proportion of time guarded by sentinels of *N. fasciata* was many times higher. In the campo-cerrado, although sentinels were identified in *N. fasciata*, their behavior in the mixed flocks was more similar to the one of the attendant species. *N. fasciata* was presumably benefited by saving vigilance time, mainly while exploiting the alertness of *C. hirundinacea*.

Willis (1972) presented evidence for bird mixed flocks as a direct adaptation to aerial predators. In Hawaii, a land without raptors, mixed flocks are absent. Morse (1973) studied mixed flocks in temperate forest and suggested the anti-predatory function to flocks as the result of the low rate of successful attacks by raptors. The alarm calls of parids were meaningful to prevent predation. Székely *et al.* (1989) experimentally verified a larger size of mixed flocks when a raptor was common in the study site. On the other hand, in the raptor absence, mixed flocks were smaller. Powell (1985) reviewed the several selective factors related to neotropical mixed flocks evolution. The predator effect is cited as the main selective factor and the predator avoidance hypothesis is widely accepted as the major advantage to neotropical mixed flocks. In this study, the variation in the time with sentinel in relation to raptor presence, the exploitation of alarm calls (Sullivan, 1984b) and the possible benefits to flocking species as exemplified by *N. fasciata* are in accordance to the concepts of the alertness as a main feature of the nuclear species and the anti-predatory function of mixed flocks.

Acknowledgments — The author is grateful to José Galizia Tundisi for logistical support at CRHEA-USP. Regina Baruki Fonseca improved the English. This work was supported with a grant from Brazilian National Research Council (CNPq).

REFERENCES

ALVES, M. A. S., 1990, Social system and helping behavior in the white-banded tanager (*Neothraupis fasciata*). *Condor, 92*: 470-474.

ALVES, M. A. S. & CAVALCANTI, R. B., 1996, Sentinel behavior, seasonality, and the structure of bird flocks in a Brazilian Savanna. *Orn. Neotrop., 7*: 43-51.

ANDREWS, M. I. & NAIK, N. M., 1979, The biology of the jungle babbler. *Pavo, 8*: 1-34.

BEVERIDGE, F. M. & DEAG, J. M., 1987, The effects of sex, temperature and companions on looking-up and feeding in single and mixed species flocks of House Sparrows (*Passer domesticus*), Chaffinches (*Fringilla coelebs*), and Starlings (*Sturnus vulgaris*). *Behaviour, 100*: 303-320.

CARACO, T., MARTINDALE, S. & PULLIAM, H. R., 1980, Avian flocking in the presence of a predator. *Nature, 285*: 400-401.

CARRASCAL, L. M. & MORENO, E., 1992, Proximal costs and benefits of heterospecific social foraging in the Great Tit, *Parus major*. *Can. J. Zool., 70*: 1947-1952.

EITEN, G., 1994, Vegetação do cerrado, pp. 17-73. *In:* M. N. Pinto (ed.), *Cerrado*: *caracterização, ocupação e perspectivas*, 2ª ed., 681p. Ed. Univ. Brasília, Brasília.

FERGUSON, J. W. D., 1987, Vigilance behavior in the white-browed sparrow-weavers *Plocepacer mahali*. *Ethology, 76*: 223-235.

GADDIS, P. K., 1980, Mixed flocks: Accipters and anti-predator behavior. *Condor, 82*: 348-349.

GASTON, A. J., 1977, Social behaviour within groups of jungle babblers, *Turdoides striatus*. *Anim. Behav., 25*: 828-848.

GREIG-SMITH, P. K., 1978., The formation, structure and function of mixed-species insectivorous bird flocks in west African savanna woodland. *Ibis, 120*: 284-297.

HEGNER, R. E., 1985, Dominance and anti-predator behaviour in blue tits (*Parus caeruleus*). *Anim. Behav., 33*: 762-768.

HOGSTAD, O., 1988, Advantages of social foraging of willow tits *Parus montanus*. *Ibis, 130*: 275-283.

HUTTO, R. L., 1994, The composition and social organization of mixed-species flocks in a tropical deciduous forest. *Condor, 96*: 1105-118.

LAZARUS, J., 1979, The early warning function of flocking in birds: an experimental study with captive Quelea. *Anim. Behav., 27*: 855-865.

LENDREM, D. W., 1983, Predation risk and vigilance in the blue tit (*Parus caeruleus*). *Behav. Ecol. Sociobiol.*, *14*: 9-13.

MCGOWAN, K. J. & WOOFENDEN, G. E., 1989, A sentinel system in the Florida scrub jay. *Anim. Behav.*, *37*: 1000-1006.

METCALFE, N. B., 1984, The effect of mixed-species flocking on the vigilance of shore birds: who do they trust? *Anim. Behav*., *32*: 986-993.

MORSE, D. H., 1973, Interactions between tit flocks and sparrowhawks *Accipiter nisus*. *Ibis*, *115*: 591-593.

MOYNIHAN, M., 1962, The organization and probable evolution of some mixed species flocks of Neotropical birds. *Smithsonian Misc. Collect.*, *143*: 1-140.

MUNN, C. A. & TERBORGH, J. W., 1979, Multispecies territoriality in Neotropical foraging flocks. *Condor*, *81*: 338-347.

POPP, J. W., 1988, Scanning behavior of finches in mixed-species groups. *Condor*, *90*: 510-512.

POWELL, G. V. N., 1979, Structure and dynamics of interspecific flocks in a Neotropical mid-elevation forest. *Auk*, *96*: 375-390.

PULLIAN, H. R., 1973, On the advantages of flocking. *J. Theoret. Biol.*, *38*: 419-422.

PULLIAN, H. R., 1985, Sociobiology and the adaptive significance of interspecific foraging flocks in the Neotropics. *Ornith. Monogr., 36*: 713-732.

RAGUSA-NETTO, J., 1997a, Seasonal variation of foraging behavior in *Cypsnagra hirundinacea* in the "campo-cerrado". *Ararajuba*, 5: 72-75.

RAGUSA-NETTO, J., 1997b, Evidence for the possible advantage of heterospecific social foraging in *Furnarius rufus* (Passeriformes: Furnariidae). *Ararajuba, 5*: 233-235.

RAGUSA-NETTO, J., 1999, *Sócio-ecologia dos Bandos Mistos de Aves em Campo-Cerrado (Brotas, SP)*. Tese de Doutorado, Universidade Estadual Paulista, Rio Claro.

RAND, A. L., 1954, Social feeding behavior of birds. *Fieldiano Zool., 36*: 5-71.

RIDGELY, R. S. & TUDOR, G., 1989, *The birds of South America. The Oscines Passerines*, 1st vol., Oxford Univ. Press, Oxford, 516p.

SICK, H., 1997, *Ornitologia brasileira*. Nova Fronteira, Rio de Janeiro, 912p.

SOKAL, R. R. & ROHLF, F. J., 1981, *Biometry*, 2nd ed., W. H. Freeman, New York, 859p.

SULLIVAN, K. A., 1984a, The advantages of social foraging in Downy Woodpeckers. *Anim. Behav*., *32*: 16-22.

SULLIVAN, K. A., 1984b, Information exploitation by downy woodpeckers in mixed-species flocks. *Behaviour*, *91*: 294-311.

SZÉKELY, T., SZÉP, T. & JUHÁSZ, T., 1989, Mixed species flocking of tits (*Parus major*): a field experiment. *Oecologia, 78*: 490-495.

VERBEEK, N. A. & BUTLER, R. W., 1981, Cooperative breeding of the northwestern crow *Corvus caurinus* in British Columbia. *Ibis*, *123*: 183-189.

WICKLER, W., 1985, Coordination of vigilance in bird groups. The 'watchman's song' hypothesis. *Z. Tierpsychol.*, *69*: 250-253.

WILLIS, E. O., 1972, Do birds flock in Hawaii, a land without predators? *Calif. Birds*, *3*: 1-8.