Acarina 5(1–2): 63–68

CHANGES IN POPULATION STAGE STRUCTURE OF AN ARGASID TICK *ARGAS ARBOREUS* DURING NESTING SEASON OF ITS HOST, THE CATTLE EGRET *BUBULCUS IBIS*, IN SOUTH AFRICA

ИЗМЕНЕНИЯ ВОЗРАСТНОЙ СТРУКТУРЫ ПОПУЛЯЦИИ КЛЕЩЕЙ *ARGAS ARBOREUS* ВО ВРЕМЯ ГНЕЗДОВАНИЯ ИХ ХОЗЯЕВ, ЕГИПЕТСКИХ ЦАПЕЛЬ *BUBULCUS IBIS*, В ЮЖНОЙ АФРИКЕ

V.N.Belozerov*, G.Kopij**

*Biological Research Institute, St.Petersburg University, Old Peterhof, 198904 Russia
**Department of Zoology and Entomology, University of the Orange Free State, Bloemfontein, 9300 South Africa
*Биологический научно-исследовательский институт Санкт-Петербургского гос. университета, Старый Петергоф, 198904 Россия
**Кафедра зоологии и энтомологии, Университет Оранжевой провинции, Блумфонтейн, 9300 ЮАР

Key words: host-parasite relationships, life cycles, seasonality, *Argas arboreus*, *Bubulcus ibis*
Ключевые слова: паразито-хозяинные отношения, жизненные циклы, сезонность, *Argas arboreus*, *Bubulcus ibis*

ABSTRACT

Development of a tick *Argas arboreus* inhabiting rookeries of the cattle egret *Bubulcus ibis* is synchronized with breeding season of its host, both in the southern (South Africa) and northern (Egypt) parts of its area. The period of tick activity (feeding of overwintered ticks, their reproduction and development of next generation) coincides with bird nesting period during spring-summer season. The overwintering reserve consisted of unfed and engorged adult ticks and nymphs II–III is formed by the end of nesting season. The univoltine developmental cycle, typical for *A.arboreus*, can be combined with bivoltine and biennial cycles (that results in an increased stability of local tick populations).

РЕЗЮМЕ

Развитие клеща *Argas arboreus*, обитающего в гнездовьях цапель *Bubulcus ibis*, однотипно сопряжено с сезонным ритмом гнездования его хозяев в южных (Южная Африка) и северных (Египет) частях его ареала. Период активности клещей (питание перезимовавших имаго и нимф II–III, откладка самками яиц и развитие личинок и нимф следующей генерации) приурочен к гнездованию птиц на протяжении весенне-летнего сезона и завершается к осени формированием зимующего запаса из взрослых клещей и нимф II–III. Моновольтинный цикл развития, типичный для *A.arboreus*, может дополняться циклами с ускоренным (бивольтинным) и замедленным (двухгодичным) развитием, что повышает устойчивость локальных популяций клещей.

The tick *Argas (Persicargas) arboreus* Kaiser, Hoogstraal and Kohls, 1964 is a common parasite of the cattle egret *Bubulcus ibis* (L.), inhabiting its rookeries all over the African continent, from Egypt to South Africa [Khalil et al., 1980].

The study of seasonal dynamics of development of *A.arboreus* in Egypt [Guirgis, 1971] has shown that the life cycle of this tick is characterized by a definite alternation of periods of active development and periods of dormancy coordinated with seasonal rhythms in the life of its host. The life cycles of similar character with complex adaptations for coordinated development are typical for ixodoid ticks parasitizing migratory birds [Balashov, 1982], e.g. for the argasid tick *Ornithodoros capensis* Neum [Filippova, 1966] and for ixodid ticks *Ixodes lividus* Koch, *I.signatus* Birula and *I.uriae* White [Filippova, 1977]. In Egypt the active feeding of *A.arboreus* ticks, their reproduction (egg-laying) and development (hatching of larvae, their moulting into nymphs, passage through 3–4 nymphal instars and the following moulting into adult ticks) are precisely dated for a spring-summer season (March—September), *i.e.* for the period of the cattle egret nesting and breeding. The period of tick activity is completed in September when birds abandon their rookeries. The overwintering stages are adult ticks and nymphs II–III which cease to lay eggs and to moult in autumn and winter (since October till March). It was also established, that the seasonal cessation of reproduction in *A.arboreus* is caused by the reproductive diapause determined in adult females by a short-day autumn photoperiod [Khalil, 1974, 1976].

Unfortunately, peculiarities of *A. arboreus* biology [Kaiser, 1966; Guirgis, 1971; Hafez et al., 1971, 1972], its physiology [Khalil, 1974, 1976; Khalil, Shanbaky, 1976; Shanbaky, Khalil, 1975] and even morphology [Kaiser et al., 1964] were investigated only for ticks from Egypt. There is only brief reference concerning the presence of autumn delays of reproduction in *A.arboreus* from South Africa [Kaiser, 1966]. We succeeded to get some additional information on biology and development

of this tick in South African Republic. The investigations were undertaken in the southeastern Orange Free State, where in a mixed rookery of the cattle egrets and sacred ibises we have found argasid ticks determined later by Dr. J. Walker (Onderstepoort Veterinary Institute, Pretoria) as *A. (P). arboreus*. In the present paper we consider seasonal changes in the stage and sexual structure of *A.arboreus* population during the nesting season of the cattle egrets (since November 1993 till February 1994) in their rookery in the South Africa and compare seasonal development of this tick in the southern (Republic of South Africa) and northern (Egypt) parts of its distribution.

MATERIALS AND METHODS

The collections of ticks were carried out in a mixed nesting colony of the cattle egret *Bubulcus ibis* (L) and sacred ibis *Threskiornis aethiopicus* (Latham) located in the Orange Free State (South Africa), on the farm Wolwekop, Dewetsdorp district (29°S, 27°E), 70 kms to the south from Bloemfontein, from the *Acacia karroo* and *Rhus lancea* trees growing on a dam in the middle of a pond. There were some single nests of the reed cormorant *Phalacrocorax africanus* and the African spoonbill *Platalea alba* in this bird colony. Ticks were collected during a 4-month period from November 1993 till February 1994 from cracks and under loosy bark on trunks of trees, where bird nests were established. All the ticks found under a bark piece (80–150 sq.cm), were fixed in 70 % ethyl alcohol. Later one of the authors (VNB) has treated the collected material for computing the portions of larvae, nymphs of I, II and III–IV instar, adult females and males. The stage structure of tick population was calculated for the sum of nymphs and adults (without larvae). The sexual structure was estimated from the ratio of adult females and males (in %% from the total number of adult ticks).

RESULTS

Changes in the bird colony. The nesting and breeding period in the rookery, numbering about 1300 nests and existing during many years, begins with returning of herons and ibises at the beginning of October, which corresponds to April of the Northern Hemisphere, and lasts till February corresponding to the northern August, when birds begin to leave the rookery. Only during this 5-month period ticks have the regular source of nourishment (at first on adult birds, and then on nestlings), which ensures their reproduction and development. Adult birds returned to the rookery become hosts for overwintered ticks (adults and nymphs II–III), while the offspring of these ticks (larvae and nymphs I) feed mainly on the cattle egret nestlings which hatch in November, fledge in December and remain in the rookery until January-February of the next year, when they disperse together with adult birds [see Kopij, 1995, 1997].

Changes in the tick population. The results of investigation concerning the changes in tick population from November till February are represented in Table and in Fig.1, A and 2.

At the end of November the investigated population of *A.arboreus* consisted of adult ticks (65%) and nymphs of III–IV instars (35%). Practically all the collected ticks were represented in November by engorged specimens, which revealed

Table

Changes in population structure of *Argas arboreus* in the Cattle Egret rookery (Orange Free State, RSA) during the nesting season of birds

Stages of ticks	November	December	January	February
Total number of ticks	143	93	77	473
Eggs	++	++	+	-
Larvae	-	++	+	+
Nymphs I	0	0	14 (18.2 %)	34 (7.2 %)
Nymphs II	0	0	37 (48.0 %)	170 (36.0 %)
Nymphs III-IV	50 (35.0 %)	34 (36.5 %)	7 (9.1 %)	3 (0.6 %)
Adult ticks	93 (65.0 %)	59 (63.5 %)	19 (24.7 %)	266 (56.2 %)
Females	36 (25.2 %)	26 (28.0 %)	9 (11.7 %)	106 (22.4 %)
Males	57 (39.8 %)	33 (35.5 %)	10 (13.0 %)	160 (33.8 %)

Notes: Symbols -, + and ++ in case of eggs and larvae mean the absence, low and high abundance of them , respectively.

active moultings at nymphal stage (showed by the presence of moulting skins), and intensive egg-layings (by adult females). Neither larvae, nor nymphs of younger instars (I–II) were detected in November. The numerous egg clutches consisting mainly from freshly layed eggs occured under the bark. An intensive larval hatching from these egg-layings in laboratory at 25°C took place at the beginning of December (in two weeks after the eggs were collected).

Collections carried out in the middle of December consisted, as well as before, mainly of adult ticks and elder nymphs, the ratio of which remained the same as in November (Fig. 1,A). There were numerous egg clusters (of developing eggs) under the bark also. The occurence of unfed larval ticks which hatched recently represented an important novelty for the tick population (under natural conditions larvae start to hatch in the last days of November already). The number of unfed larvae

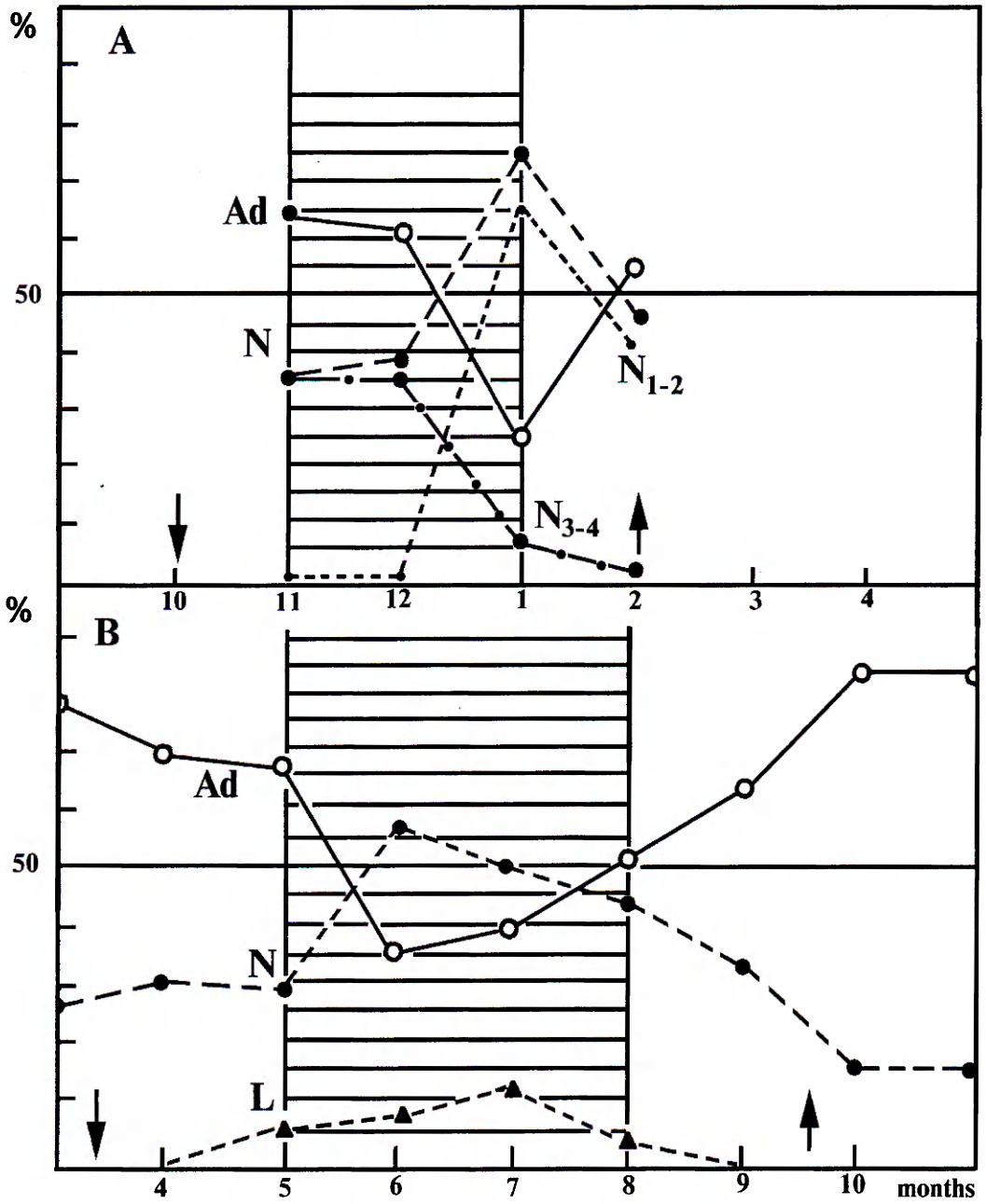

Fig.1. Seasonal changes in the percent ratios of different life-cycle stages in *Argas arboreus* populations in South Africa (A) and in Egypt (B): Ad – adult ticks, N – nymphs (all instars), N_{1-2} – nymphs of I–II instar, N_{3-4} – nymphs of III–IV instar, L – larvae. Breeding periods of the cattle egrets are shown by striped columns. Beginning of bird return to rookeries in spring and their dispersal from them in autumn are designated by arrows I and – respectively. The diagram for ticks in Egypt is composed after Guirgis [1971].
Рис.1. Сезонные изменения в процентном соотношении различных стадий развития в популяциях *Argas arboreus* из Южной Африки (А) и Египта (В): Ad – взрослые клещи, N – нимфы всех возрастов, N_{1-2} – нимфы I–II возраста, N_{3-4} – нимфы III–IV возраста, L – личинки. Периоды выкармливания птенцов цапель показаны заштрихованными колонками. Стрелки I и – показывают начало возвращения птиц на гнездовья весной и осенней миграции соответственно. График для клещей из Египта составлен по данным Гургиса [Guirgis, 1971].

under the bark was, however, much fewer than it would be possible to expect from an abundance of eggs. Larval ticks were met this time more often on fledged nestlings of the cattle egret, the main hosts of *A. arboreus* at larval stage (it is of interest to note that we did not manage to find the larvae on nestlings of the sacred ibis). Practically all the nestlings of the cattle egret were parasitized by *A.arboreus* larvae happened to stay at different stages of engorgement (the feeding of larvae in *Argas* ticks lasts 4–11 days, while the engorgement of its nymphs and adult ticks is completed in some 30 minutes). We never found the engorged larvae on trunks of trees (under the bark or in cracks of it where the engorged nymphs and adults take their shelter). It is possible to suggest that the engorged larvae develop in the litter and debris under trees (after drop-off the host), as was shown for Egyptian ticks [Guirgis, 1971].

In the middle of January the structure of tick population has undergone strong changes, caused mainly by an appearance of nymphs I and II, which corresponded to18 and 48% of the whole nymphal-adult population. A portion of elder nymphs (III–IV) and adult ticks revealed simultaneously a remarkable reduction in comparison with the previous term (from 37 up to 9 % in nymphs and from 63 up to 25 % in adult ticks).

Changes in population stage structure observed at the end of February were revealed mainly in further reduction of nymphs III–IV (they occured only as single specimens).The number of younger nymphs (I–II) decreased also (their portion in February was reduced up to 7 and 36 %, respectively), whereas the number of adult ticks has increased and reached the level (56 % of population) which was characteristic for November-December (63–65 %). There were some single unfed larvae in February samples, but the laying of eggs was stopped by adult females by this time already.

Sexual structure of the investigated population of *A.arboreus* is characterized by permanent predominance of adult males (Fig. 2, A). It was especially evident at the beginning and at the end of nesting season (adult males comprised 61 and 60% of all adult ticks, respectively), whereas in the middle of this season the sex ratio turned for about equalling and the number of males decreased up to 53–56%.

The number of ticks in the rookery during the whole nesting season of birds was very high. In February we have carried out the more accurate registration of ticks hidden under the bark on three *Acacia* trees during the day time. There were collected 160±12.5 ticks from a shelter under the bark piece of 120 (100–150) sq.cm, including 11.3 ±9.1 nymphs I, 56.7 ±13.5 nymphs II, 1.0 ±0.8 nymphs III and 88.7±12.8 adult ticks.

DISCUSSION

Our data on changes in the stage structure of *A. (P). arboreus* population testify that the life cycle of this tick in South Africa, as well as in Egypt [Guirgis, 1971], is precisely coordinated with seasonal rhythm of its host, the cattle egret *Bubulcus*

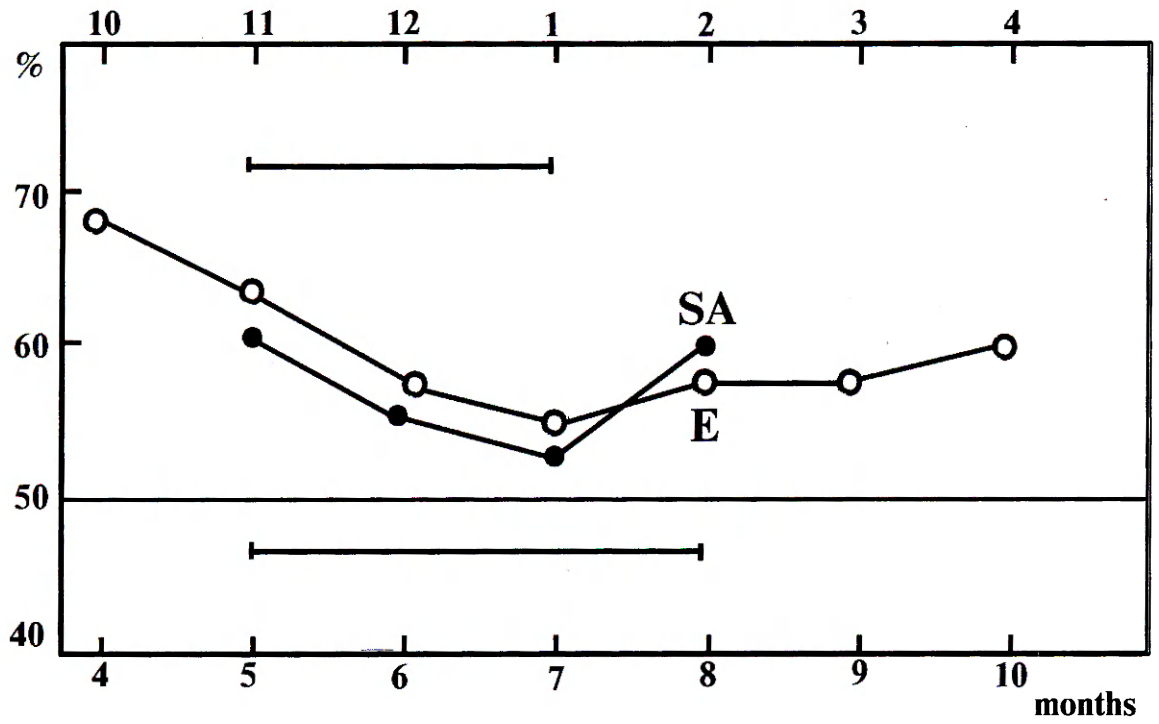

Fig.2. Seasonal changed in the male predominance (% of males in adult ticks samples) in *Argas arboreus* populations from South Africa (SA) and Egypt (E) in regard to breeding seasons of its host (shown by horizontal lines).
Рис.2. Сезонные изменения в преобладании самцов (% самцов в выборке взрослых клещей) в популяциях *Argas arboreus* из Южной Африки (SA) и Египта (E) по отношению к сезонам размножения (показаны горизонтальными линиями) их хозяев.

ibis, in particular with seasonality of the bird nesting and breeding. Reproduction and development of these ticks inhabiting the rookeries occur only during this period which falls on the spring-summer season (from the end of March till September in Egypt and from the beginning of October till February in South Africa). The rest of year, falling on autumn and winter, ticks spend in the state of dormancy.

In Egypt, according to Guirgis [1971], the winter period is survived by dormant adult ticks and nymphs of II–III instars (both unfed, and engorged), and the main part of the overwintering reserve (70–83 % of it) is composed by adult ticks. The ratio of nymphs and adults does not vary during autumn and winter (Fig. 1, B). It remains about the same at the beginning of nesting period (April–May) also, when overwintered hungry ticks attack the returning birds, and hide themselves after engorgement under the bark and in its cracks, where nymphs start to moult, and adult females begin to lay eggs (simultaneously with ticks overwintered in engorged state). The similar picture is found by us in South Africa (Fig. 1, A), where the ratio of adult ticks and nymphs under the tree bark at the initial stage of nesting period (November–December) remains constant, and similar in proportion to that ratio in Egypt. This confirms the similarity of *A.arboreus* from these regions relative to structure of overwintering population also. Essential changes in stage structure of tick populations begin in Egypt since May, and in South Africa since December, when larval hatching is followed by the fast development nymphs of the next generation. These changes are revealed in regular (and similar for both regions) increase of nymphal portion and in corresponding reduction of adult portion (Fig. 1, A, B). At the same time, as it follows from our data with differential registration of nymphal instars, an increase of the whole nymphal portion in South Africa occurred only at the cost of nymphs I-II, whereas the number of elder nymphs (III–IV) revealed the remarkable reduction (Fig. 1, A) due to their transformation into adults. It is possible to suppose that similar distinctions in dynamics of elder nymphs belonging to overwintering generation, and of younger nymphs belonging to the next (daughter) generation, are peculiar to the same extent also to egyptian population of *A.arboreus*. At the end of nesting season (since July in Egypt and since January in South Africa) tick populations reveal new changes, opposite to former in direction and caused by their preparations for overwintering. They are displayed in an increasing of adult portion of ticks (due to the role of *A.arboreus* adults as the main overwintering stage), and in simultaneous reduction of the nymphal portion (due to proceeding transformation of nymphs into adults).

It is necessary to note, that changes in sexual structure of *A.arboreus* populations in southern and northern parts of Africa during nesting period of the cattle egrets are also very similar (Fig. 2).

Thus, different geographical populations of *A.arboreus* demonstrate principal similarity concerning seasonal changes of their stage (and even sexual) structure. At the same time, they reveal some quantitative distinctions, e.g. in dynamics of these changes (namely in their stretching). Their comparison (after reconciling the equal seasonal phases) shows that these changes in population stage structure begin in Southern Africa one month later and run in the shorter period than in Northern Africa (Fig.1, A,B). The probable reasons for these distinctions may concern the peculiarities of seasonal changes of temperature in regions under consideration.

The tick *A.arboreus,* both in northern, and in southern parts of its area, as it is followed from the data on seasonal changes in its population structure, is characterized by univoltine development which is well synchronized with seasonal phenomena of its hosts. This type of developmental cycles (with one generation to be completed during one year) is peculiar to the greater parts in both populations of *A.arboreus* (to 75–85 % of them according to the portion of adults among overwintering ticks). Undoubtedly, the maintenance of univoltine development in *A.arboreus* is ensured mainly by reproductive diapause arising in engorged females as their response to the autumn shortening of day-length [Khalil, 1974, 1976]. The bivoltine cycles (with two generations a year) are possible in Egypt [Guirgis, 1971] due to a facultative character of reproductive diapause. But in South Africa, where the season of tick activity, as it is shown above, is shorter, it is quite probable that a part of population can complete its development in two years. Such a biennial development resulted from the ability of unfed elder nymphs and adult ticks to survive during 8-14 months [Guirgis, 1971; Hafez et al., 1971, 1972] is quite possible in Northern Africa also. The combination of these types of development (univoltine, bivoltine and biennial) keeping phase coordination by means of diapause delays of reproductive processes in females (and, probably, of developmental processes in nymphs) in *A.arboreus*, as well as in other ticks [see Belozerov, 1976], is of great adaptive importance, as it enables an increased resistance and stability of their local populations.

Seasonal adaptations controlling the alternation of activity and dormancy (e.g. seasonal photoperiodism) are of great importance in controlling the life cycles of ixodoid ticks [Belozerov, 1976, 1982]. In *A.arboreus* they need more attention in further researches. This concerns, for instance, the seasonal delays of development in engorged nymphs and the seasonal loss of aggressiveness in unfed nymphs and adult ticks. The special importance of these adaptations is ensued from a maintenance of normal annual cycle of activity and dormancy in *A.arboreus* even in a case of disturbed seasonal rhythm of bird nesting reported by Guirgis [1971] when overwintering ticks retained the dormant state despite the abnormal nesting and breeding of birds through the winter.

ACKNOWLEDGEMENTS

The field work was supported by the University of the Orange Free State, South Africa, and the laboratory treatment of field collections by Russian Foundation of Basic Research (Grant 96–04–48267). The help of Dr. J.Walker (Onderstepoort Institute of Veterinary Research) in tick determination, of Prof. O.J.Kok (University of OFS) in bird study consultations, and of Ms.& Mr. Theron, the owners of the farm Wolwekop, is highly appreciated.

REFERENCES

Balashov Yu.S. 1982. [Host-parasite relations of Arthropods and terrestrial Vertebrates] / L., "Nauka". 319 s. [in Russian]

Belozerov V.N. 1976. [Life cycles and seasonal adaptations in Ixodid ticks] // Dokl. 28 Chteniy Pamyati N.A. Kholodkovskogo. «Nauka». S.53–102. [in Russian]

Belozerov V.N. 1982. Diapause and biological rhythms in ticks // Physiology of Ticks (F.D.Obenchain and R.Galun, eds.). Pergamon Press. P.469–500.

Filippova N.A.. 1966. [Argasid Ticks (Argasidae). Fauna of USSR. Arachnoidea] / T. IV. Vyp.3. "Nauka". 255 s. [in Russian]

Filippova N.A.. 1977. [Ixodid Ticks of Subfamily Ixodinae. Fauna of USSR. Arachnoidea]. T.IV. Vyp.4. "Nauka". 296 s. [in Russian]

Bassal T.M. and Roshdy M.A. 1974. *Argas (Persicargas) arboreus*: Juvenile hormone analog termination of diapause and oviposition control // Exper. Parasitology. Vol.36. №1. P.34–39.

Guirgis S.S. 1971. The Subgenus *Persicargas* (Ixodoidea, Argasidae, *Argas*). 11. Ecology and seasonal dynamics of *A. (P.) arboreus* in Egypt // J. Med. Entomol. Vol.8. №4. P.407–414.

Hafez M., Abdel-Malek A.A. and Guirgis S.S. 1971. The Subgenus *Persicargas* (Ixodoidea, Argasidae, *Argas*). 12. Biological studies on the immature stages of *A. (P.) arboreus* in Egypt // J. Med. Entomol. Vol.8. №4. P.421–429.

Hafez M., Abdel-Malek A.A. and Guirgis S.S. 1972. The Subgenus *Persicargas* (Ixodoidea, Argasidae, *Argas*). 14. Biological studies on the adult stage of *A (P). arboreus* in Egypt // J. Med. Entomol. Vol.9. №1. P.19–29.

Kaiser M.N. 1966. The Subgenus *Persicargas* (Ixodoidea, Argasidae, *Argas*). 3. The life cycle of *A. (P.) arboreus*, and a standardized rearing method for Argasid ticks // Ann. Ent. Soc. Amer. Vol.59. №3. P.496–502.

Kaiser M.N., Hoogstraal H. and Kohls G.M. 1964. The Subgenus *Persicargas*, new subgenus (Ixodoidea, Argasidae, *Argas*). 1. *A. (P). arboreus*, new species, an Egyptian *Persicus*-like parasite of wild birds, with a redefinition of the Subgenus *Argas* // Ann. Ent. Soc. Amer. Vol.57. №1. P.60–69.

Khalil G.M. 1974. The Subgenus *Persicargas* (Ixodoidea, Argasidae, *Argas*). 19. Preliminary studies on diapause in *A. (P.) arboreus* // J. Med. Entomol. Vol.11. №3. P.363–366.

Khalil G.M. 1976. The Subgenus *Persicargas* (Ixodoidea, Argasidae, *Argas*). 26. *Argas (P.) arboreus*: effect of photoperiod on diapause induction and termination // Exper. Parasitology. Vol.40. №2. P.232–237.

Khalil G.M. and Shanbaky N.M. 1976a. Hormonal control of diapause in the tick *Argas arboreus* // J. Insect Physiology. Vol.22. №12. P.1659–1663.

Khalil G.M. and Shanbaky N.M. 1976b. The Subgenus *Persicargas* (Ixodoidea, Argasidae, *Argas*). 25. *A. (P.) arboreus*: effect of temperature on diapause termination // Exper. Parasitology. Vol.39. №4. P.431–437.

Khalil G.M., Hoogstraal H. and Oliver J.H., Jr. 1980. Biological evaluation of the systematic validity of the African *Argas (Persicargas) arboreus* and the Asian-Australian *A. (P). robertsi* (Ixodoidea, Argasidae) // Intern. J. Parasitology. Vol.10. №2. P.253–259.

Kopij G. 1995. Breeding biology of the Cattle Egret *Bubulcus ibis* in Dewetsdorp district, Free State Province // Mirafra. Vol.12. P.8–9.

Kopij G. 1997. Timing of colony occupation, clutch size and breeding success in the Cattle Egret *Bubulcus ibis* related to nest location in a South African heronry / / Acta Ornithol. Vol.32. №2.

Shanbaky N.M. and Khalil G.M. 1975. The Subgenus *Persicargas* (Ixodoidea, Argasidae, *Argas*). 22. The effect of feeding on hormonal control of egg development in *A. (P). arboreus* // Exper. Parasitology. Vol.37. №3. P.361–366.