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Insects of forensic significance in Argentina

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Abstract

Records from forensic expertises and trappings with beef baits conducted in Buenos Aires, Argentina (34°36′S), show that the dominating species are widespread ones (*Calliphora vicina* and *Phaenicia sericata*), with different behaviour in each large latitudinal zone. It is suggested that the range of the yearly photoperiod variation has an influence in the behaviour of the blowflies, making up for differences in the succession patterns. The Calliphorid blowflies *Cochliomyia macellaria* and *Chysomya albiceps* were found on indoors corpses; the latter also on outdoors corpses when blood was shed, and in that case as primary. Three species of beetles of the genus *Dermestes*, which had been associated with mummified remains, appeared 10–30 days after death. The Silphid beetle *Hyponecrodes* sp. cf. *erythrura* was found on outdoor copses in rural environments. The Nitidulid beetle *Carpophilus hemipterus* was found in association with the cheese skipper *Piophila* sp. (Diptera: Piophilidae) in medullar cavities of bones after ca. 30 days; to this association is often added the Clerid *Necrobia rufipes*. Lepidoptera Tineidae appear on the head of mummified indoors corpses. North of parallel 32°S, the Muscid grave-fly *Ophyra* sp. was found breeding on a corpse outdoors in summer. A division by latitude and climate is proposed for Argentina, and an extended system is proposed for the world.

Keywords: *Calliphora*; *Phaenicia*; *Ophyra*; *Carpophilus*; Photoperiod variation

1. Introduction

Methodical studies of insects found on human corpses have been conducted in Argentina only, since 1993 (expertises) and 1996 (trapping and rearing at Buenos Aires). Expertises are based on determination of species and stages of development of individuals in samples sent in by medical experts of the official Forensic Medical Corps. The greatest number come from Buenos Aires Federal District (Capital Federal), latitude taken as 34°36′S, through the Forensic Medical Corps of the National Justice Department (Cuerpo Medico forense de la Justicia Nacional).

2. Material and methods

Trapping is being conducted at Buenos Aires City, with beef as bait. Jars are placed in containers with water, as a deterrent to the Argentine ant *Linepithema humile* (Mayr, 1868). Post-feeding larvae are transferred to gardening sphagnum moss for pupariation. Daily records on macroscopical changes of the bait are recorded, together with maximum and minimum temperatures and their hour of recording, as well as sightings of adults on the bait, oviposition, development of larvae, pupariation and emergence of adults. These are determined by the use of keys by Mariluis [1,2]. The nomenclature in this papers has also been followed, hence, the use of the name *Phaenicia sericata*. Nomenclature, one must point out, is the competence field of taxonomists, in this case of the specialists in Muscoidea. The extension of the genus *Lucilia*, and the attribution of some species to *Phaenicia*, is a matter of discussion, and it appears quite clear that it can only be settled by a revision of *Lucilia sensu lato* for the whole world. Pending this, one should follow the criterium of one of the taxonomists. It may be pointed out that the species placed in *Phaenicia* by Mariluis and in *Lucilia* by European authors are those which have invaded large areas of the world and become near-cosmopolitan, while the species with Paleartic, or Paleartic plus Neartic distributions belong to *Lucilia sensu stricto*. This argues a different behaviour, weightier than the morphological characters which may be deemed rather trivial to justify the splitting of the genus *Lucilia*. Also, field observations by European authors [3] have made abundantly clear the heliophily of common species of *Lucilia*, and the contrast of their behaviour with that of *Calliphora* spp.

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P. sericata certainly does not show heliophily in Buenos Aires. The tolerance of this species to poorly illuminated oviposition sites has been discussed in [4].

3. Results

The two species found on the bait with the greatest frequency proved to be very widespread ones: the bluebottle *Calliphora vicina* Robineau–Desvoidy, 1830 and the greenbottle *P. sericata* (Meigen, 1826) (Diptera: Calliphoridae). Contrary to literature based on European data [3], at Buenos Aires these species do not alternate spatially, but seasonally [5]. At first, it was supposed that the activity of the adults might correlate to ranges of absolute temperatures. However, oviposition records for over 3 years show a more complex pattern. Both species may oviposit at the same time, especially at the end of spring (November–December), when bluebottles are replaced by greenbottles.

October 1996 began with low temperatures for the season (Fig. 1, light stippling: *C. vicina*; dark stippling: *P. sericata*; squares: ovipositions; tringles; adults; circles: larvae; diamonds: pupae). It can be observed that the first oviposition by *P. sericata* followed a drop in mimimum temperature and coincided with a rise in this (Fig. 1). Ovipositions by *C. vicina* and *P. sericata* during the last 3 months of 1996 are recorded in Table 1. On the 30 November (Fig. 2, light square) a bluebottle was observed ovipositing at 18.45 h, on the lower side of the bait (suggesting behaviour to avoid sunlight). The last conjoint oviposition of the year occurred on the 1 December (Fig. 3, light and dark squares).

So far, data confirm the well-known fact that greenbottles prefer warmer weather than bluebottles, as suggested by their brilliant sheen which should enable them to endure warm sunlight. But in January 1997, there was a single greenbottle oviposition (Fig. 4, 23–31.4°C). The weather was very hot during this month (minimum seldom below 20°C, maximum above 30°C, as high as 34.6°C). For the first months of 1997, the weather remained warm, moderated by rainy spells; temperature rarely fell below 16°C. However,

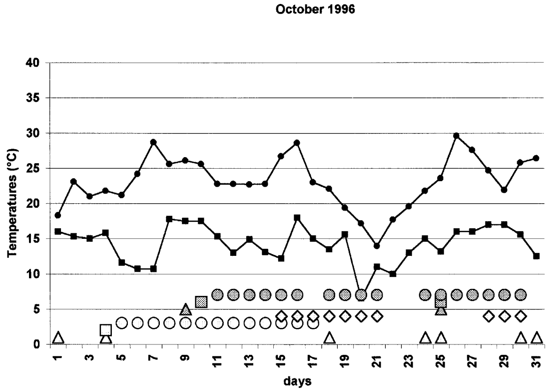


Fig. 1.

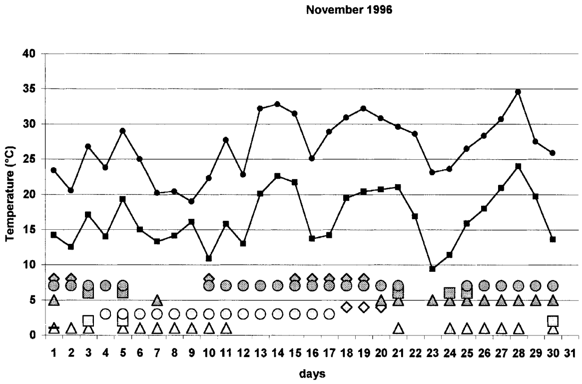
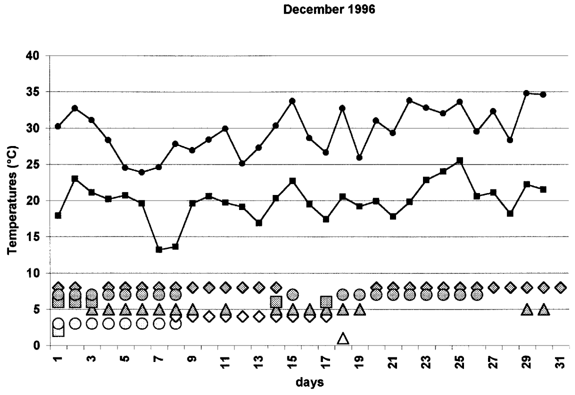


Fig. 2.

Table 1
Ovipositions in October–December (spring) 1996 [5]

Date	Minimum temperature (°C)	Maximum temperature (°C)	Oviposition by *C. vicina*	Oviposition by *P. sericata*
4 October 1996	15.8	21.8	*	
10 October 1996	17.5	25.6		*
25 October 1996	13.2	26.6		*
3 November 1996	17.1	26.8	*	*
5 November 1996	19.3	29	*	*
21 November 1996				*
24 November 1996	11.4	23.6		*
30 November 1996	13.6	25.9		
1 December 1996	17.9	30.2	*	*
2 November 1996				*
3 November 1996				*
14 December 1996	20.3	30.2		*
17 November 1996	17.4	26.6		*



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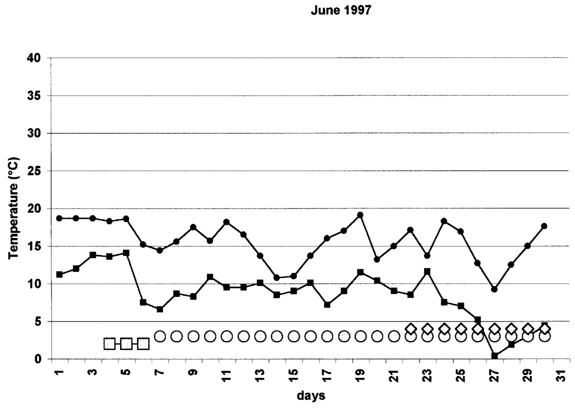

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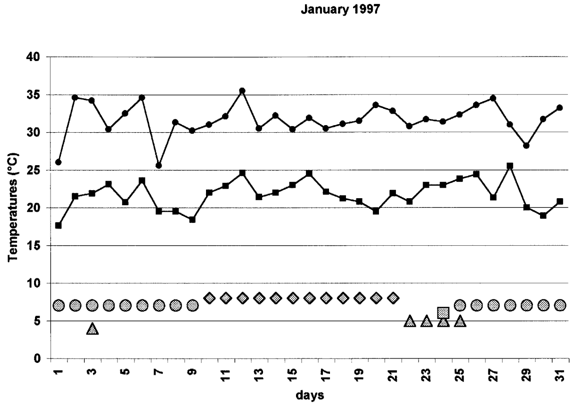


Fig. 4.

for a few days at the end of May (middle fall), the minimum dropped below 5°C. After a gradual rise in temperature, the first oviposition by *C. vicina* was recorded the 4–6 June (Fig. 5, temperatures: 13.6–18.3, 14.1–18.6 and 7.5–15.2°C). When a hiatus appears between February (middle of summer) and March–April (early fall), it is partially filled by the yellow coffin-fly *Megaselia scalaris* (Loew, 1866) (Diptera: Phoridae) and to a lesser degreee by fleshflies *Parasarcophaga* spp. (Diptera: Sarcophagidae). These were the results that I took into account in my paper of 1997 [5]. (Table 2).

Warm summers (21 December to 21 March) are the rule at Buenos Aires. But 1998 was an unusual year all the world round. The weather was rainy, or clouded and windy, moderating the heath (Fig. 4, Table 3). *P. sericata* oviposited the 10 January (Fig. 6, square); then for some time the weather was moderately warm but with minimum temperatures remarkably variable, (14–23°C); greenbottles were observed feeding (Figs. 6 and 7, dark-stippled triangles), but did not oviposit until the 10 February (Fig. 7). Figs. 6–9 show the remarkable variation in temperature for the first 4 months of 1998. On the 16 February, there was an interesting record of two greenbottles ovipositing together at 11:00 a.m. (Fig. 7). The first record of *C. vicina* (Fig. 8, light square) on the 20 March coincided with a small drop in the minimum

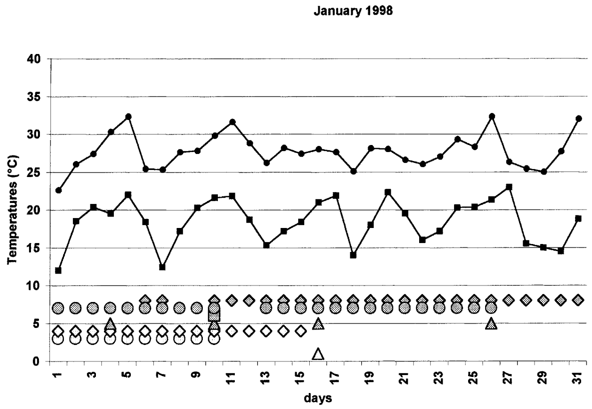
Table 2
Results for 1996–1997 [5]

Month	*C. vicina*	*P. sericata*	*Parasarcophaga spp*	*Megaselia scalaris*
January	Not found	No oviposition	All stages	All stages
February	Not found	No oviposition	All stages	All stages
March	Not found	Not found	Not found	Larvae
April	Not found	Not found	Not found	Not found
May	Oviposition begins	Not found	Not found	Larvae, pupae
June	All stages	Not found	Not found	Pupae, adults
July	All stages	Not found	Not found	All stages
August	All stages	Not found	Adults	Not found
September	All stages	Not found	Larvae	Larvae, pupae
October	All stages	Oviposition begins	All stages	Pupae
November	All stages	All stages	All stages	All stages
December	All stages	All stages	All stages	Not found

Table 3
Ovipositions in January–April (late summer–early fall) 1998

Date	Minimum temperature (°C)	Maximum Temperature (°C)	Oviposition by *C. vicina*	Oviposition bt *P. sericata*
10 January 1998	21.6	29.8		*
10 February 1998	12.6	26.4		*
16 February 1998	21.6	29.5		*
20 March 1998	17	28.8	*	*
7 April 1998	13.9	18.8		*
8 April 1998	14.5	21.4		*
9 April 1998	9	20.9	*	*

temperatures, but it should be noted that on the 11 March there had been an abrupt descent in temperatures, which may have activated the aestivating females. As to *P. sericata*, the record (Fig. 8, dark square) falls within a spell of mild weather with a rising trend. The fall begins on the 21 March; on April 1998 (Fig. 9), there was mild weather with the maximum around 25°C, minimum rising steadily then dropping on the 7 March, when there was oviposition by *P. sericata* (dark squares), repeated on the 8 and 9 March, when there is also a record of *C. vicina* (light square) coinciding with an abrupt drop in minimum temperature. A small drop in the minimum temperature after a short steady rise stimulated the greenbottles, but it took an abrupt drop below 10°C to activate bluebottles.



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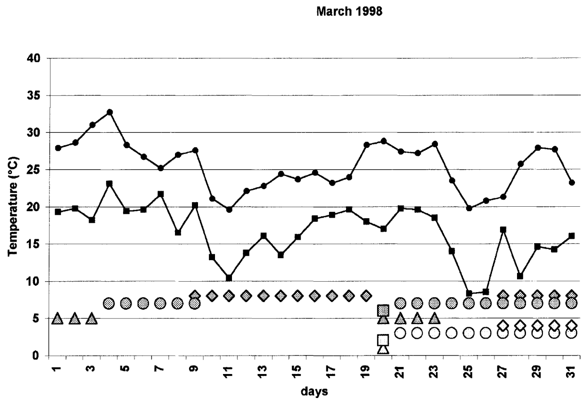

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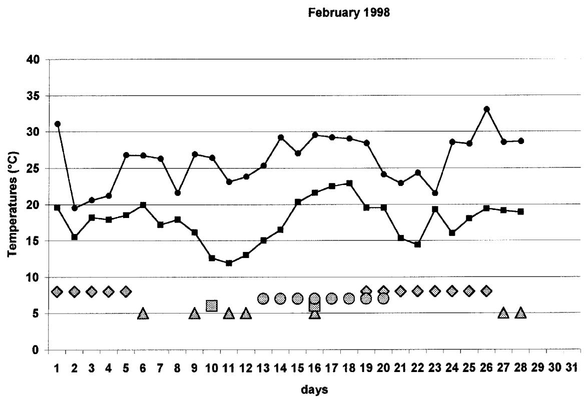

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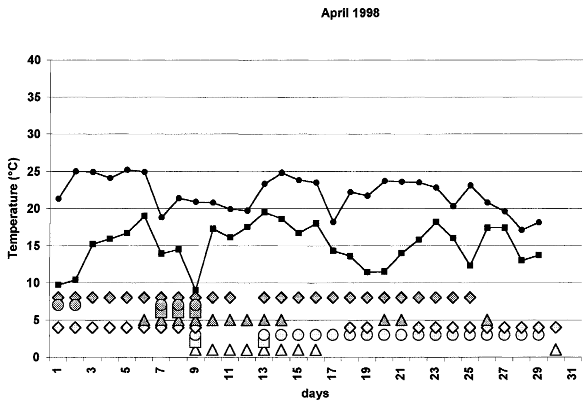

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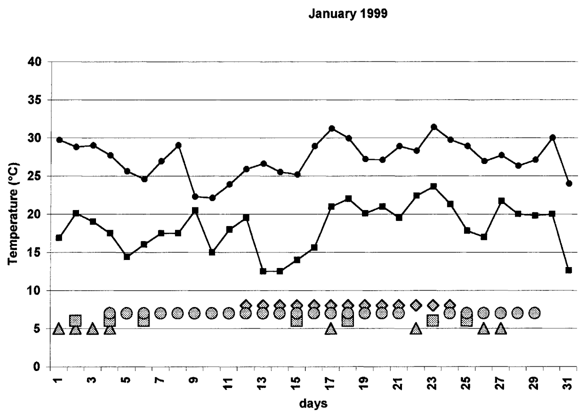

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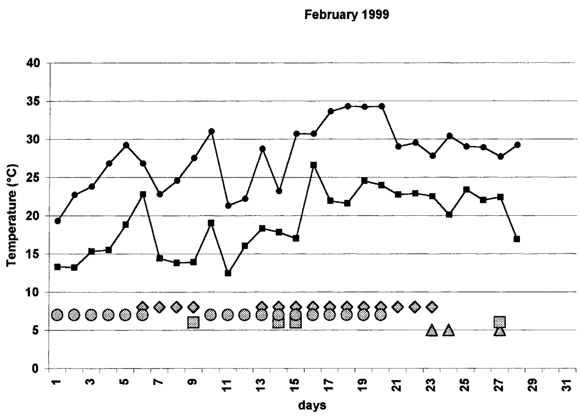

Fig. 11.

January 1999 (Fig. 10) was cool for Buenos Aires: only in 2 days, did temperatures rise above 30°C. Ovipositions in January–April 1999 (summer to early fall) are recorded in Table 4. Seven greenbottle ovipositions (squares) were recorded, none on the warmer days. February presents a more irregular pattern (Fig. 11) with oviposition on the 9, 14, 15 and 27 February (female observed 13.45 h). The time spacing between the two last ovipositions corresponds for the greatest part to a heat wave (Fig. 11). Eggs laid on the 27 February could not be determined as parasitoids attacked every blowfly pupa on that sample. It seemed safe to asume that *P. sericata* is not (or seldom; cf. Fig. 4) active with maximum temperatures above 29°C. Yet, it tolerates them at the beginning of its season. In March 1999, both greenbottles and bluebottles oviposited Fig. 12, dark and light squares respectively). The 13 March there was an oviposition by *C. vicina* alone. Afterwards the weather kept warm but variable, and a steady drop of minimum temperatures from the 23 March onwards ended in oviposition by *C. vicina* on the 28 March, when a drizzle lowered the maximum, and by both species on the sunny 29–31 March (Fig. 12, squares: oviposition; triangles: adults; circles: larvae).

Activation of aestivating females of *C. vicina* appears to depend on one or more peaks of low minimum temperatures; however, the same species is quite tolerant of high minimums at the end of spring. On the other hand, *P. sericata* appears to be stimulated out of hibernation by a rise in temperature with large daily fluctuation, and is not deterred by a maximum above 30°C; yet in summer it stops ovipositing with a maximum above 29°C or with high minimums which reduce daily variation. Although they do not oviposit, adults may be seen feeding on carbohydrates, such as grapes exposed for sale. Since these responses vary seasonally, it is proposed that the photoperiod influences them. The actual difference between the temperature ranges favoured by each species is slight. The photoperiod hypothesis might explain why in Europe, where insect activity stops in winter, *C. vicina* and *P. sericata* alternate spatially (through a preference for sunlight or shadow), while in warmer climates they alternate along the year. Temperature imposes itself so forcibly, that one tends to forget that it reflects geographical latitude, and therefore, a range of photoperiod yearly fluctuation. Many other insect activities are known to be influenced by the photoperiod; very recent studies on the

Table 4
Proposed latitudinal zones

Zones	Latitude (°)	Yearly photoperiod variation (h)
Polar	From 65	10–24 (winter day too short for blow fly development)
Subpolar	65–55	7–10
Cold-temperate	55–48	6–7
Temperate	48–39	5–5.75
Warm-temperate	39–32	4.25–4.75
Subtropical	32–25	3–4
Tropical	Up to 25	Negligible

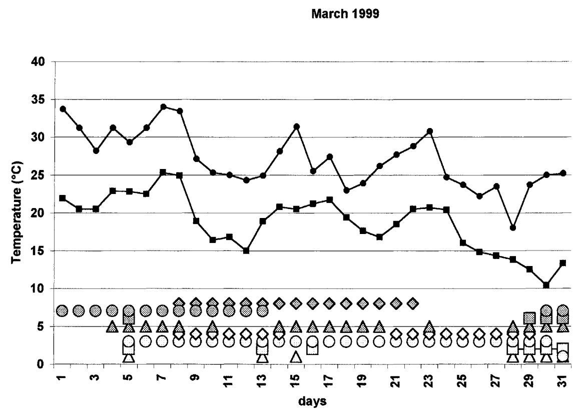

Fig. 12.

effect on the biological "clocks" have been presented in [6,7].

In December 1998 (early summer), I received a sample from a corpse lightly buried out of doors. It showed such a healthy population of *Ophyra* sp. (Diptera: Muscidae) that at first I pronounced that it must surely have been hidden indoors. In my preceding expertises, samples with *Ophyra* sp. (in any stage of development) in numbers exceeding several times those of other species had been from either indoors or buried corpses [5].

It turned out that the corpse had been placed inside a small but abrupt ravine caused by flow of rainwater in a loose, sandy soil. At the site, I satisfied myself that this was the widest part of the ravine, and a corpse already advanced in decay could hardly have been transferred from some other place without leaving some sign. The place of the crime was a small town north of 32°S, where at the end of December (beginning of summer) temperature reaches high values. The sandy banks, sparesely shadowed by the foliage of *Eucalyptus saligna* shoots, would have provided a warm microhabitat. One could hardly be reminded in a clearer way that this is already a different climate from Buenos Aires. Baharudin [8] kindly confirmed that he had had similar cases from Malaysia, In fact, although book-lore tells us that *Ophyra* species live in graves or in dry, heated man-made places, it appears obvious that they are tropical insects which, like so many others, drifted towards the poles as man provided them with adequate habitats. In this locality, I remarked that ants of the genus *Camponotus* (Hymenoptera: Formicidae) prevented the quite abundant greenbottles *Chrysomya albiceps* (Wiedemann, 1819) and *C. megacephala* (F., 1775) from colonizing beef bait in the first 48 h; their feeding bored the beef through with tunnels more than 5 mm in diameter (the beef was still in a moist state at this time).

In the province of Neuquen (Fig. 13), where the arid climate makes for a very broad daily variation en March–April, *P. sericata* is active at this time of the year, but needs 25–30 days to complete larval development and 40–45 days for adult emergence.

The above findings led me to propose a division of Argentina into zones (subject to further refining), as follows: (1) north of 25°S (tropical); (2) 25–32°S (Subtropical); (3) 32–39°S (warm-temperate); (4) 39–48°S (temperate); (5) south of 48°S (cold-temperate). Each of these should be divided into humid and arid, corresponding roughly to plains and mountains, although aridity is caused also by other factors (Fig. 13). Arid climates make wider daily variations of temperature, which usually delay maggot development [9]. The few data available from the cold-temperate zone (5) suggest that the behaviour of the flies here will prove rather like that observed in western Europe.

This zones correspond roughly to (1) difference in length of midsummer and midwinter days negligible; (2) difference 3–4 h; (3) difference 4.25–4.75 h; (4) difference 5–5.75 h; (5) difference 6–7 h. Above 60 degrees, length of winter day is negligible. This hardly matters in Argentina, where the mainland ends at a lower latitude, while Antarctica is covered in ice the year round [10].

That a difference of as little as 5° might influence necrobiontic insects was already suggested by [11], working with rats as a model in Temuco, Chile. However, he was comparing as well humid climate with arid. According to [6], populations of *C. vicina* from different latitudes show different lengths or intensities of diapause. A strain 36°N showed diapause when reared (as it transpires from the text) in Scotland, it would be interesting to study this point at the original latitude.

A similar system might be applied to the whole world, as the divisions based on zoogeography [3] are of little value for work on forensic insects. In the first place, these maps are often based on phytogeographic data, and therefore, excellent for phytophagous fauna, but not for zoological means. Secondly, autochthonous necrophages are usually pushed aside by the very opportunistic, synanthropic species, and these appear to vary their pattern of behaviour according to latitude. One should aim at a model which would enable a researcher starting in an unstudied country to make some estimate of what might be found there, and to choose such references as may provide the most direct guidance. Arctic zones are defined as having a negligible winter photoperiod; I propose to set the limit at 65°, subject to further refining. The behaviour of blowflies adapted to such climates is quite different from that of widespread species which dominate in lower latitudes [12]. As mentioned, I set the limits for the tropical zone at 25°. This leaves us with two zones extending for 40° latitude which, however, should not be divided evenly, as the Earth is not spherical in shape (Fig. 14). Taking the values of yearly photoperiod variation, the following zones are proposed: arctic, subarctic (65–55°); cold-temperate (55–48°); temperate (48–39°); warm-temperate (39–32°); subtropical (32–25°); Tropical. This corresponds roughly to yearly variation (Table 4).

The zones should be subdivided, at least into humid and arid climates; this may lead to a discrimination between tropical climate (dry and rainy seasons) and equatorial climate (rain in all seasons). It is to be expected that the definitive borders will not follow man-defined lines. The basis of these divisions should be determined by the way insect behaviour is affected by factors stemming from the geographic situation. Traditional zoogeographical divisions as given in [3] ought to be considered, as they will make themselves felt in the fauna as of secondary importance (Table 5).

3.1. Size of insects

Another observation made through the repeated rearing of *C. vicina* was a considerable intraspecific diversity of size, which, however, is not apparent in every insect-series obtained. As a rule, adults of *C. vicina* are about 8–9 mm long, which corresponds to a thoracic length in dorsal aspect

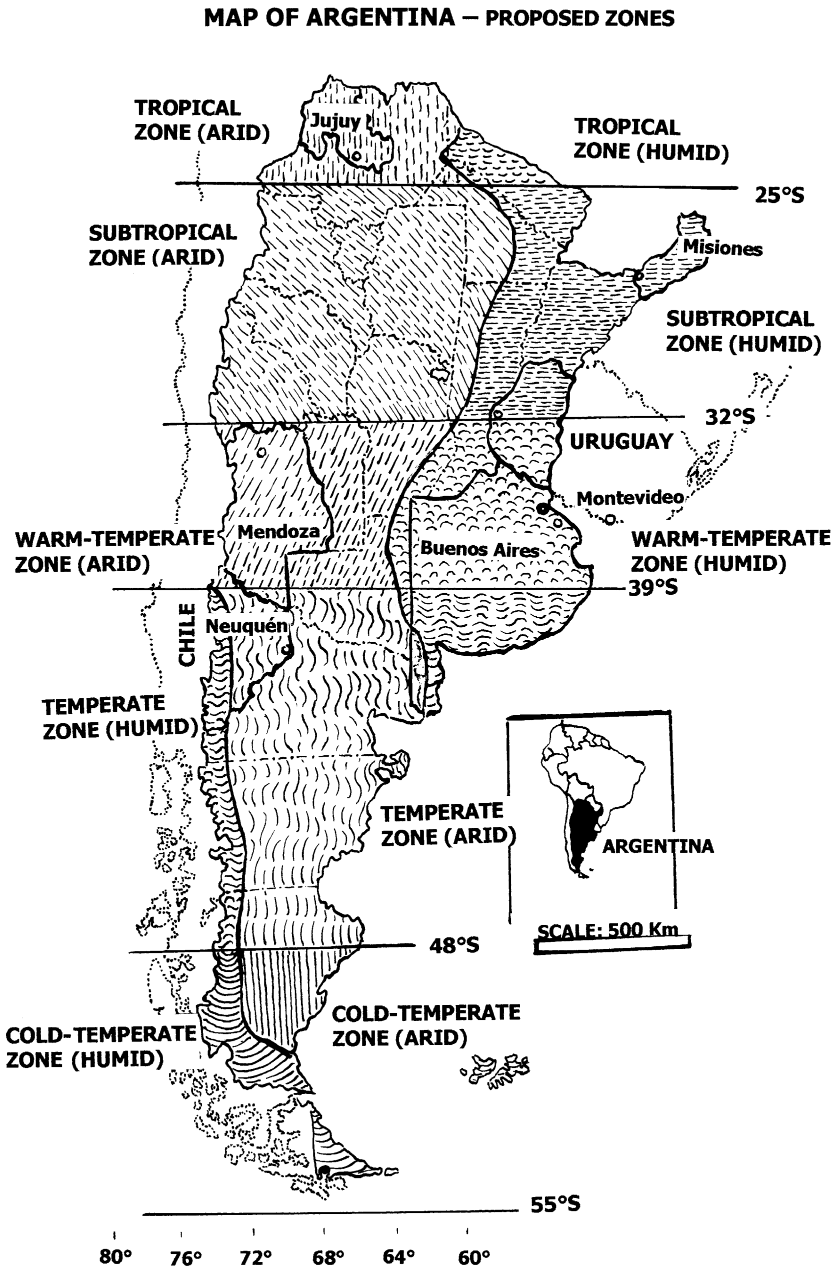

Fig. 13.

of 3.2–3.7 mm. This measurement is often the only one which can be made on every specimen recovered dead, as the abdomen distorts with drying and the wings and legs are easily broken.

The first females to oviposit each year after aestivation were about the size stated above. The mature larvae attain a length of 15–18 mm. Yet at different times throughout the year, series with a binormal pattern were obtained. Small individuals were about 10 mm long as mature larvae and 6–6.5 mm long as adults (thoracic length about 2.8 mm). The sex ratio was about even for both size-norms. This abundance of small individuals is often associated with exceptionally cold spells, but more study is needed on this subject. Unfortunately, methodical mathematical treatment of preserved series had to be postponed because of several mishaps.

Several factors may affect the size of an insect with complete metamorphosis. As a rule, larvae in unfavourable environments hasten their development, which appears

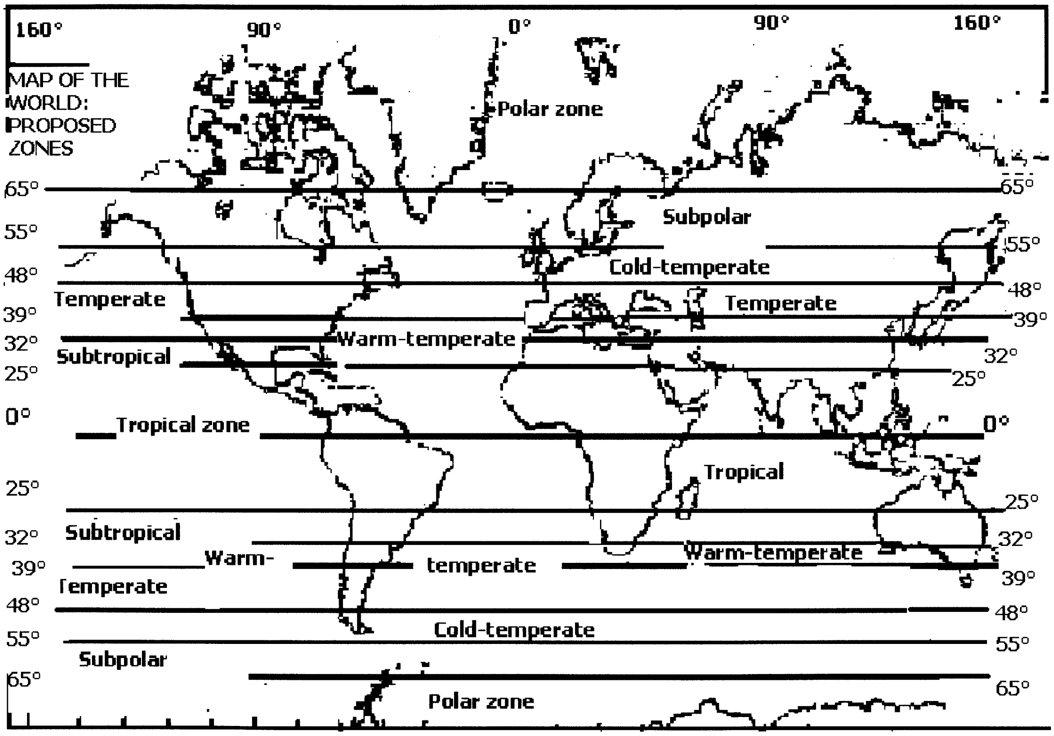

Fig. 14.

logical as the adult is the form that can go away and seek more favourable habitats. This is seen very often in aquatic Coleoptera of pioneering species [13], larvae developing in temporary water bodies, which risk drying up, often produce small adults, sometimes not more than half the usual size, but otherwise normal. In these species it is not rare to find large series of adults in a similar state of sclerotization (therefore, of a similar age), with considerable intraspecific variation of size, and also of other characters. While size may be a more or less direct result of food or territory availability, the wide range of variability, and the fact that this appears also for other characters which do not have a direct environmental cause, suggest that these species actually tend to produce offspring with a broad range of genetically determined character. This would be efficient for a pioneering species, as it would ensure at least some individuals adapted to the microhabitat in which they find themselves. Indeed, in such genera as *Berosus* (Coleoptera: Hydrophilidae), which have many species with different modes of life, pioneering species show a broad range of intraspecific diversity, while species which are selective as to their habitat usually do not [13]. It seems possible that a similar mechanism is present in such groups of Diptera as have species with a wide tolerance of habitats. The advantage of this in the case of the saprosarcophagous flies is obvious.

3.2. Myiasis

The mechanism proposed above may be the explanation for certain cases of myiasis in which larvae were eliminated by the patient or removed by the physician during lapses of several weeks. In 1999, I was able to examine material from one case of cystomyiasis and four cases of ophtalmomyiasis (several localities in the agglomeration around Buenos Aires, in the southestern area); in every case, I identified the parasite as *Psychoda* sp. In one case, larvae were extracted from the patient's eye several times during a period of about a month and a half. Since the patient lived in good

Table 5
Criteria for characterization of areas

Base of division	Latitude	Humidity	Zoogeography
Effects	Type of response to temperature	Length of development	Faunal elements other than synanthropic spp.
Acts through	Photoperiod variation	Daily temperature variation	Complex

conditions of hygiene, the simplest explanation is that a single clutch of eggs was laid, in which some were of early hatching, some middling and some late.

3.3. Behavioural observations

In populations of *C. vicina* with a broad intraspecific size variation, it was remarked that the larger maggots tended to stay under the beef bait, while the smaller climbed out of the jar in large numbers, and had to be rescued from water or trapped in vessels half-filled with gardening sphagnum moss, into which they burrowed readily. However, when population was large, a good number of large maggots also climbed out. The series of adults do not show a definite slant towards a larger size for individuals remaining near the original bait (data still in process of evaluation).

3.4. Further novelties

Diptera: Calliphoridae, *Cochliomyia macellaria* (F., 1775) is common on indoor corpses, even in winter (21 June–21 September). Another Calliphorid of the same subfamiliy, *Chysomya albiceps*, was found frequently from November (late spring) to May (late fall). Neither species was reared from baits, perhaps due to a preference for large carcasses; however, adults of *C. albiceps* did feed on beef baits in the late summer. More remarkable is the fact that *C. albiceps* exhibited two quite different patterns of behaviour. In outdoors cases involving considerable bloodshed (knifings), the fly behaves as a primary and may arrive at the body in a few minutes. In one case at Buenos Aires (March 1999), the body of an adult was skeletonized in about 20 days to such a point that the remains were taken directly to the Anthropology department. In indoor cases *C. albiceps* behaves as a secondary fly, often following the Sarcophagidae in succession. In these cases, there are usually masses of older maggots, which are probably the actual attractant. Certainly, mature larvae of Sarcophagidae are found disembowelled together with feeding larvae of *C. albiceps*.

Coleoptera, the three species of *Dermestes* (Dermestidae) recorded for Argentina in association with decomposed human remains (*D. maculatus* De Geer, 1774, *D. peruvianus* Castelnau, 1840, *Dermestes* sp. aff. *ater*) may appear after not more than 10 days, although a more frequent lapse is 25–35 days after death, The same species are also attracted to mummified remains. It should be remarked that the extremities of a corpse may decay at a much quicker rate than the trunk. This is one of the points where practical knowledge should correct theory.

The beetle *Hyponecrodes* sp. (cf. *H. erythrura* Blanchard 1840) (Coleoptera: Silphidae), associated with small carcasses in the field, has been recovered from human corpses in rural environments. Young larvae were found with the adults, but fully developed larvae (after 35–45 days from death) appeared alone; this suggests that there is no parental care as in *Nicrophorus*.

The small beetle *Carpophilus hemipterus* (L., 1758) (Nitidulidae), a widespread species associated with stored products, was found in association with the cheese skipper *Piophila* sp. (Diptera: Piophilidae) in the marrow cavities of bones. The corpse of a child from Argentina: Neuquen (Fig. 13) and the carcasses of several animals from Uruguay: Montevideo [14] yielded these species, together with *Dermestes maculatus*, *D. peruvianus* and *Necrobia rufipes* (De Geer, 1775) (Coleoptera: Cleridae). The last species is interesting, because in autopsies at Buenos Aires *N. ruficollis* (F., 1775) proved far more abundant than *N. rufipes* [5]. Officer M. Carril tells me she observed adult *C. hemipterus* preying on the cheese skippers.

Lepidoptera: Tineidae, the two most common species of clothes-moths, *Tineola bisselliella* (Hummel) and *Tinea pellionella L.*, were found on the head hair of indoors corpses. The first species appeared in December (end of spring), along with empty puparia of *Parasarcophaga* sp. and *Ophyra* sp., and *Necrobia ruficollis* in all the stages of development; PMI estimated c. 6 months [5]. The second species appeared in May (middle fall), along with empty puparia of *C. vicina* and *Ophyra* sp., larvae of *Dermestes peruvianus* and adults of *Necrobia ruficollis*; PMI estimated 20–22 months. Therefore, in both cases death had occurred in winter, when decomposition proceeds slowly because of low temperatures and of a moderate to low activity of flies.

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