

Contribution to the knowledge of *Tomares ballus* (Fabricius, 1787)

(Lepidoptera : Lycaenidae)

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Abstract

The authors have followed *Tomares ballus* in a particular habitat of the Var (Provence, South-East France) for seven years (more than 120 hours of field observation). They observed appearance and behaviour in relation to habitat, in particular, egg laying on different host plants. They continue their studies partially in the wild and partially in captivity, investigating the development of the caterpillars and their relationship with ants. The vulnerability of this species in relation to its environment is the question that arises.

Key-Words

Tomares, ballus, Lycaenidae, behaviour, larval food plant, caterpillar, Var, France.

Introduction

The Provence Hairstreak (*Tomares ballus*) is a butterfly of the Lycaenidae family and is widespread in North Africa and the South-Western Europe (the Iberian Peninsula above all). Several small, isolated populations are known in the south of France, mostly in the Var, near Toulon (Descimon & Nel, 1986 ; Settele *et al.*, 2008), and in the Var hinterland, near La Motte. In North Africa the populations are most abundant in Morocco, Algeria and Tunisia (Tolman & Lewington, 2002). *Tomares ballus* is not found in crystalline Provence, the Isles of Giens and Hyeres, nor in the Maures and Esterel Massifs (Descimon & Nel, 1986), however this butterfly is seen on the edge of these massifs, along the Permian depressions (red earth) (Bence *et al.*, 2009). A small population survives in the Bouches du Rhone in the Gemenos area (Andre Chaulliac 13th April 2010 ; personal comment.).

Tomares ballus flies in one generation (a single flight species) from mid-March to mid-April varying from year to year. This butterfly has a rapid flight skimming the ground, and blends in well with

its surroundings. The eggs are laid on various leguminous plants (Fabaceae). It over winters as a chrysalis.

The First Encounter

After moving to Callas in the Var in 1996, we began our search for *Tomares ballus*. This elusive little butterfly was one of the first butterflies of spring which we might find in the first rays of sunshine, warming itself on the stones in old pastureland. We decided to prioritise this whole region south of Callas opposite the Colle de Rouet because it seemed to be an ideal habitat for this species. Despite several excursions from the beginning of spring to the Grand Siai and to Beaujeu, we had to wait another few years before we could add this butterfly to our list.

During the very hot and dry spring and summer of 2003, the Var was subject to devastating fires. To the south of Callas, Beaujeu was not spared and most of the vegetation was burnt twice over. Beaujeu, an old abandoned pastureland, is in the middle of *garrigue* situated about 20km from the coast and at an altitude of 147m on the edge of the crystalline massif, where sheep graze once or twice a year, thus preventing the grasses from invading the land. From the north the habitat is protected by pines and on the south and east the land is bordered by *garrigue* where typically the following species grow *Cistus albidus*, *C. salviifolius*, *Phyllyrea angustifolia*, *Rhamnus alaternus*, *Arbutus unedo*, *Erica arborea* as well as *Quercus ilex*, *Q. coccifera*, *Q. pubescens*, *Genista scorpius* and *Sarothamnus scoparius*. Tufts of lavender colour and perfume some of the ground.

In 2004 there was hardly any rain from January to April. On the 14th April we visited Beaujeu around 4 o'clock to list the vegetation and any butterflies following the forest fires of the preceding year. All the shrubs and all the thyme had disappeared and where there was once thick undergrowth it had been replaced by an area of fire-blackened trunks and branches with here and there little blades of grasses and green shoots amongst the red rocks. The buds of burnt cork oaks bravely opened their leaves.

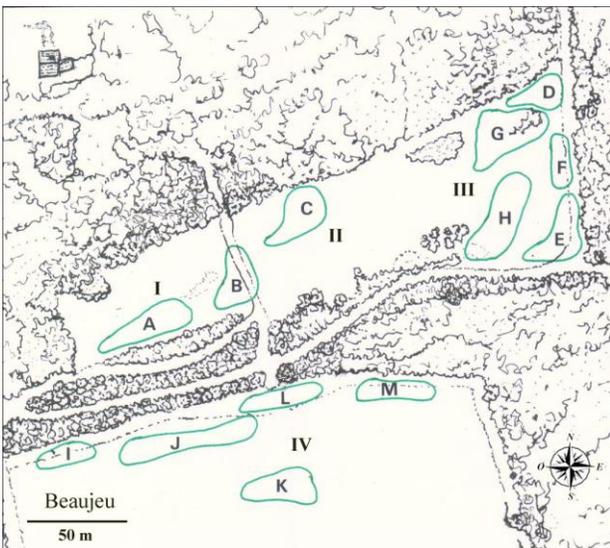
We were about to leave when our attention was drawn to a remarkable small green butterfly. In front of us was a beautiful *Tomares ballus*. A male resting, head to the wind, between several big red stones made us stop in our tracks. On the 28th, as soon as we could, we returned, and were lucky enough to see a female at about 3 o'clock most likely looking for host plants. Much of the burnt soil was covered again with *Medicago*, a host plant for *Tomares ballus*, that seemed to have benefited from the fires. *Dorycnium hirtum* seemed also to have benefited from this new situation. Perhaps the forest fires have played an important role by creating a suitable habitat for the *Tomares ballus* population.

Methods & Techniques

Between 2004 and 2010 we studied, and filmed this population and we noted that from year to year the number of adults fluctuated as did the host plants chosen by the females. To better understand the situation at Beaujeu, we divided this old pastureland into sections from I to IV and zones A to M (see plan), in which we observed different behavioural patterns of *Tomares ballus* over the years.

The focus of our study is on the behavioural patterns of this species observed in their chosen environment at Beaujeu. To better understand the development of the caterpillars, a small number of them were taken into captivity into conditions closely resembling their natural habitat. We filmed their way of life and various characteristics were photographed.

For every visit we recorded the cloud cover (%), the wind speed (Beaufort) and temperature (°C); all this data has been transcribed into a table on which this article is based.



Plan : Site of Beaujeu

Variations in Adult Appearance

We noted that the underside of the upper wing bears small black spots which vary between individuals. When resting, it is difficult to differentiate between males and females because their wings are always closed. Only when they are on the wing is it possible to accurately determine the gender. In effect the upper wings vary according to the sex; that of the male is dark brown (plate I : 2) that of the female has bright orange spots on a dark brown background (plate II : 11).

By studying the photographs and the films, it is possible to distinguish each from the other and get a better understanding of an individual's behaviour and also determine the number of males and females. This data is integrated in the tables.

The colour of the forward under-wings of a newly hatched adult is a soft green tone (plate IV : 13, 14) which verges on blue-green (plate IV : 15) after a few days.

Generally, the patterns are identical on both sides, but to our great surprise we saw that some individuals have asymmetric designs.

Males in their Territory

Although we read in the literature that *Tomares ballus* is one of the first spring butterflies (Cano *et al.*, 2008), and we went regularly to look for them from the end of February, we never saw them before the end of March in this habitat (Comment added by the editor: yet this butterfly flies regularly around 20th March in the Bandol region). From 2005 we recorded the first *Tomares ballus* flying from the first week of April peaking around 7th April. The males are more easily spotted while they watch over their territory. They are very active and take up fixed positions on dried sprigs or on stones, from where they watch each passing insect. As soon as another male passes through his territory, the resident male immediately flies off in pursuit of the intruder, chasing it in a turbulent flight, then returns to his perch (plate I : 1).

This behaviour is mostly seen from about 2 o'clock and continues until the end of the afternoon. In the morning the males can be seen resting or drinking from Cat's Ears (*Hypochaeris radicata*) or on thyme, then they disappear into the undergrowth in an instant. Before 2 o'clock the males are barely active. The territorial behaviour of the males was observed in 2005 and 2006 in zones A to E and this behaviour disappeared in zones A to C during the following years. In 2005 and 2006 territorial behaviour was seen

in zones A and B, whilst in 2007 and 2008, males no longer perched in zones D and E.

Although we visited Beaujeu regularly in 2009, during the flight period, only 2 males were spotted in zone D.

We have no idea why *Tomares ballus* wasn't found in zone A between 2007 and 2009. In zones B and C grasses had smothered the host plants. It's likely that the males require a good site with a clear view, sheltered from the wind which often blows at this time of year. It could be that the presence of the host plants plays an equally decisive role in the male's choice of his territory. In effect, in 2004 and 2005 there was a lot of *Medicago* in section I, but from 2006 onwards, these plants were progressively smothered by the vegetation. Zone D was still used as territory. This zone is positioned next to zone G where up until 2008 another host plant *Dorycnium hirsutum* was growing. Males were never sighted in section IV.

To our great surprise, on 6th and 10th April, 2 males were seen in the tall grasses on high perches in zone A. It's remarkable that these males come back to areas overgrown with grasses, which at first sight seem barely suitable. Throughout the flight period, one or several males were seen in zone D. Frequently, young males tried to establish themselves in what appeared to be the preferred location in zone D, but were chased away by the dominant (oldest) male.

In 2007 and 2008, only one male was spotted in a clearing at Pourcieux, at the lower edge of Beaujeu.

Courtship Flight

Although we closely followed this population for seven years we have only witnessed four courtship flights.

In the first case the female seemed to refuse the male. On 2nd April 2006 around half past two a perching male spotted a female which had arrived in his zone and he flew immediately to meet her (plate I : 2). The female moved off, followed by the male (plate I : 3). The latter positioned himself in flight just above her, then landed on the ground in front of her. The female flew away a few centimetres followed by the male. Annoyed, the female beat her wings energetically several times and retreated from the male (plate I : 4). In haste she flew off pursued by the male.

Two years later on the same date, around 3:30pm a female slowly flew from zone G towards zone D and came to rest on a bare patch of ground. Immediately she was spotted by a perching male which came over and settled behind her. The female

moved away, pursued by the male, then flew off and landed on top of a *Cistus cotonneux* on the edge of the field in zone D. The male followed her like a shadow and tried to mate with her: but the female wasn't at all interested (plate I : V), because she distanced herself circling the leaves. She flapped her wings several times and after a while flew off into the *garrigue* followed by the male and unfortunately then out of sight.

On 10th April 2010, at 4:15pm a female slowly made her way into a male territory in zone D, then came to rest on the ground, beating her wings; the male saw her and came to settle behind her. The female moved off a few centimetres and the male flew away. Then the female slowly crossed the territory in flight. The male busily patrolling saw her again and came to meet her. The two butterflies made a tour of the boundaries of the territory in a turbulent flight then went into the *garrigue* to a *cistus* where they mated until 5:19pm, whilst the wind blew persistently. We could see the main differences in colour of the posterior wings of the two butterflies. The newly hatched female's, a shade of moss green, and the older male's, blue-green (plate I : 6).

Watching this flight helps us to understand their behaviour: the females hatched in the morning mature during the day and leave around 3 o'clock in search of males in their territories. A female attracts the male's attention on entering his territory and settles down there. The male spots her and goes to meet her, tries to mate with her which the female refuses first time then moves off, followed by the male; than they take off in a rapid flight which ends in mating in the *garrigue*.

Several days later on 19th April, this hypothesis was confirmed. In effect the same behaviour from a female at 4:20pm slowly entering the territory in zone D, she settled in nearly the same place as the preceding female. The male placed himself behind her, attempting a match. It seemed to us that mating took place in the middle of the territory; and yet the female distanced herself, beating her wings and flew off 30cm further away. This ritual was repeated two more times flying fast in a semi-circle over zone D, then they went off into the *garrigue* and landed on a *Phyllyrea angustifolia* where they mated until 5:55pm (plate I : 7, 8). In both instances the place where the couples settled was 6m to the north of the territory, and the females positioned themselves high up.

There are several points in this behaviour that explain why the courtship flight had previously escaped our attention. Firstly, it generally takes place in the late afternoon, about the time we normally were leaving the site. Secondly, it happens very quickly

and needs a well trained eye to be able to following the butterflies flying into the *garrigue* where mating takes place. This courtship flight can easily be mistaken with the flight of a male chasing another one crossing his territory.

Egg Laying and Host Plants

In 2005 and 2008 we were able to see females laying their eggs. It is interesting to note that, depending on the year, they chose different host plants growing in the different zones of Beaujeu. It probably guarantees a better survival rate for the eggs and caterpillars (Mann,1999). All the host plants used for egg-laying are leguminous from the *Fabaceae* family. The small pearly-green eggs, 1mm in size, are laid on various plants, hidden between the leaves. Egg laying normally begins during the first week of April and takes place between noon and 3pm. The female butterfly lays from one to three eggs at a time, resting in between laying, drinking nectar from thyme (plate II : 6) and from Lucerne and less often from *Potentilla erecta* and *Brassica nappa* (plate II : 9). She relaxes and gathers strength before moving off again in search of suitable host plants on which to lay her next lot of eggs.

Medicago polymorpha

Even though several kinds of *Medicago* were found at Beaujeu, in particular *M. minima* and *M. orbicularis*, only *M. polymorpha* was selected for egg laying.

In 2005 in zone A, in 2006 in zone B and in 2007 in zones B and L, the eggs were laid mostly on *M. polymorpha*. This plant is a ground creeper and grows mostly in places that are bare and have no grass. The females settle on top of the horizontal stems, and with antennae curved forwards, lay their eggs between the leaves (plate II : 12-14). On 3rd April 2008 in zone K, an egg had been laid on the top of a leaf from this plant.

Although this *Medicago* species is widespread in section IV, very few females were seen except in zones K, L & M. laying their eggs. On 10th April 2010, we watched a female laying several eggs amongst the *M. polymorpha* plants which had invaded zones J & K.

Dorycnium hirsutum

In 2008, a large part of the habitat was overgrown with grass. Twisting stems of *Cistus albidus* had developed in zone H. Despite the progressive invasion by grass, following the fires of

2003, a greater variety of vegetation had become established, offering suitable plants on which the female *Tomares ballus* lay their eggs. Several plants of varying heights were growing between the *Cistus cotonneux*, amongst them *Dorycnium hirsutum*, on which several eggs had been laid on 4th & 6th April (plate II : 3 - 5).

The females that were studied preferred small plants in poor state, no more than 5cm in height. Before laying her eggs between the leaves, the butterfly first delicately feels the edge of the plants with her antennae and abdomen. The female then lays one to three eggs on each plant, resting a moment in between layings. On 4th April, in zone G, eggs were recorded on several plants and two days later another female in zone H demonstrated the same behaviour as previously observed. In between laying she drank nectar from thyme.

In 2009 and 2010 *Dorycnium hirsutum* had become scarce in zones G & H following grazing by sheep in 2008.

Dorynium pentaphyllum

On 3rd April 2008 a female laid her eggs on several well developed specimens of *D. pentaphyllum* growing at the edges of zone E between *Cistus cotonneux* in the *garrigue* (plate II : 1-2). This host plant has never been cited in the literature. We watched the same behaviour as the female carefully climbed up the plant whilst testing the stems here and there in order to find the ideal spot for laying her eggs.

On 19th April there was a female searching for host plants in the *garrigue* in the north east of zone D, where only *D. pentaphyllum* grows amongst the *cistus* at Beaujeu

Scopiurus muricatus & Anthyllis tetraphylla

On April 8th 2007 a female carefully inspected some *Scopiurus muricatus* plants intending to lay her eggs there (plate II : 10, 11). Even though we watched her for more than ¼ of an hour, we couldn't find any eggs. It's uncertain if this species is a chosen host plant. The same female left eggs on the same day on *Medicago* species which was growing close by. Strangely, the presence of *Anthyllis tetraphylla* growing in abundance did not attract any females even though this is one of *T. ballus* preferred host plants (Diringer, 2007). Apparently the chosen plants vary with habitat. *Scopiurus muricatus & Anthyllis tetraphylla* have not been found at Beaujeu since 2008. We don't know if these plants were present in

2005 and 2006. In 2010 these plants were growing once again in the big field (IV) between zones L & K.

On the 12th April, we went on a field trip with Luc MANIL to explore some know sites near Bandol and Cues where we recorded the presence of these host plants as well as several *Medicago* species.

Rearing Caterpillars in Captivity

Since we had never found any *T. ballus* caterpillars, even though we searched meticulously on the various host plants, we decided in 2008 to dig up some of the *Dorycnium hirsutum* plants in Zone G, on which eggs had been laid on 4th April, in order to be able to follow the development of the caterpillars once they hatched. We chose plants with only one egg, because it's described in the literature that some caterpillars whilst in captivity exhibit cannibalistic behaviour (Tolman & Lewington, 1999).

The Effects of Grazing

In zones G and H, little markers were placed next to the eggs so that we could also follow them in their natural environment, from stage L1. We had read that the *T. ballus* caterpillars could be associated (myrmecophily) with *Plagiolepis pygmaea* (Fieldler, 2006). From Section IV, Zone K we took a *Medicago* plant with an egg which had been laid on the 3rd April.

On 22nd April we were surprised to see in zone G, a flock of sheep fenced-in, in an area about 30m in diameter, exactly the place where we had marked the plants (plate II : 7). The following days the sheep were still there and the vegetation had gone at a dramatic rate. A week later a large part of Beaujeu had been razed, and where the sheep had been, there was only a layer a few centimetres thick with their droppings (plate II : 8). None of the markers could be found. At the edge of the field, in the south of Zone H, a few sparse plants of *Dorycnium hirsutum* were found on which eggs had been laid.

On the east edge of Section III, in Zones E and F, buried amongst the Cistes of the *garrigue* were some *Dorycnium pentaphyllum* plants left behind by the sheep which tend not to venture into the *garrigue*. Eggs laid in these zones could have benefited from this natural protection (plate II : 2).

The Development of the Caterpillars

We can identify on the caterpillars back from the 2nd thoracic segment to the 6th abdominal segment, 2 bumps per segment: the dorsal "fender belt" (diagram 1). On both sides of these segments the

lateral "fender belt" are found. During the development of the caterpillar these "fender belt" become more and more pronounced. Because of these, the shape of the caterpillar becomes less and less recognisable and offers protection. On the first thoracic segment we see the occipital plaque, under which the caterpillar shields its retractable head from the ants whilst they feed.

Partial myrmecophily

The *Tomares ballus* caterpillars are in effect myrmecophilous, but they are not dependent on the ants for their development. On the middle of their 7th abdominal segment the caterpillars have a transversal aperture, or Newcomer's gland, also called dorsal glandular nectar organ (DNO). On the 8th segment just after the last pair of stigmas two small cream coloured projectile organs (sort of tentacles) are found, the eversible tentacle organs (TO), which can be pushed out. It contains a gland which excretes a substance rich in amino acids and carbohydrates that the ants find irresistible. In return, the ants probably protect the caterpillars from other insects or parasitic enemies. The two tentacles probably emit a pheromone making the ants attentive and extremely alert. (Mann, 1999). We have often seen this interaction with ants which collect the secretions coming from the Newcomer's gland and also the excitement demonstrated by the ants as soon as the caterpillar extends it's tentacles. It could be that the caterpillars send out ultrasounds to call the ants (Mann, 1999; Elfferich, 1998)

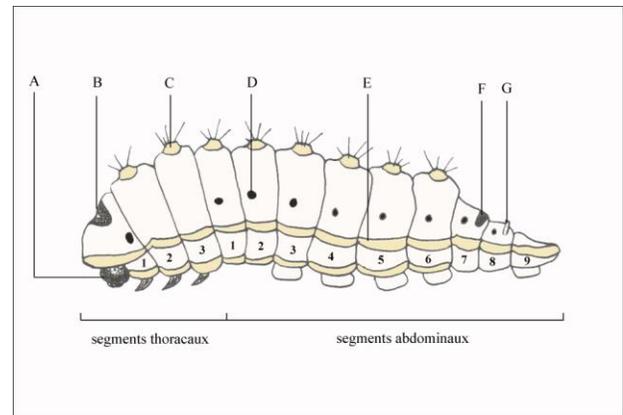


Diagram 1

- | | |
|-----------------------|---------------------------|
| A. Head retractable | E. Bourrelets latéraux |
| B. Occipital plaque | F. Glandular nectar organ |
| C. Bourrelets dorsaux | G. Tentacle organs |
| D. Stigmata's | |

Larval Stages

L1 : The first larval stage (L1): On the 24th April the egg laid on *Medicago polymorpha* hatched, the 1mm caterpillar is black and brown in colour, with long hairs on each segment. (plate III : 3). The occipital plaque is black and oval; the last three segments are much darker.

Once it has completed the tour of the leaf, it orientates and goes straight to the yellow flower buds, into which it disappears, and begins to feed on the petals (plate III : 4). For four successive days the caterpillar remains hidden in the same place, eating and resting.

L2 : On the 28th, the caterpillar is a pink colour after its first moult, with brown dorsal stripe, flanked on either side by yellow dorsal “fender belt” (plate III : 5, 6). The prothoracic shield remains oval and black (plate III : 6). On the 7th segment we see the Newcomer’s gland (DNO) like a small trace. Curiously there is also a gland on the last (or 9th) segment “a red spot” (plate III : 5) which secretes a substance (diagram 2). The caterpillars frequently hang abdomen out of the plant, probably to attract the ants. The caterpillar on *Medicago polymorpha* only eats the petals, and then moves off the plant in search of new flowers.

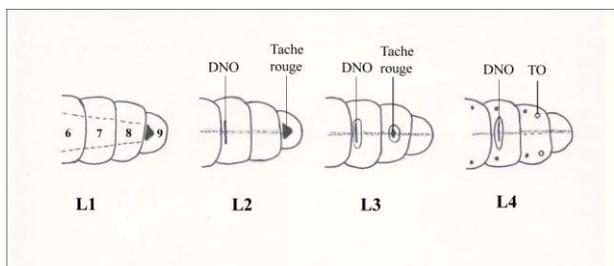


Diagram 2

L3 : On the 2nd May, the caterpillar has moulted for a second time and becomes darker with a dark red dorsal stripe and is hairier. The prothoracic shield has grown larger and is triangular. The dorsal “fender belt” are still yellow and are more obvious. The last three segments have turned Bordeaux red. The red mark (diagram 2) is now clearly visible in the middle of the 8th segment and the DNO is still visible on the 7th segment (plate III : 9). The white “fender belt” start to form.

For the first time the caterpillar begins to eat the fruits of the plant as well as the petals (plate III : 7). It begins with the spikes of the fruit before eating the fruit itself (plate III : 8). The following days the caterpillar becomes increasingly active and moves around the different plants. It is practically invisible

between the fruit and flowers because of its camouflage. On the 6th May it positions itself on a leaf, ready to moult (plate III : 9).

L4 : On the 7th May moulting is complete. The caterpillar has grown: the occipital plaque is now white coloured with a typical H-shaped design. The dorsal stripe has become black. The yellow dorsal “fender belt” as well as the white “fender belt” have become more accentuated. The stigmata’s are easily visible in the form of little black dots. Above these we see on each side a small diagonal trace. The last three segments are a darker red (plate III : 11, 12). Now the TO gland is activated, regularly attracting ants. Each segment becomes hairier and the busy caterpillar continues to feed on petals and fruits. On the 12th it works its way towards a lateral branch and prepares for the final moult.

L5 : On the 13th, the caterpillar moults for the last time. The appearance of segments 6 – 9 stays the same. The cross bar of the H-shape disappears leaving a pattern of 2 parallel lines (plate III : 14). On the body we see some dark markings: the dorsal and lateral “fender belt” are highly accentuated, and so are the small diagonal traces (plate III : 13, 15). The spiracles are shiny black; the caterpillar becomes more and more excited and feeds irregularly, spending a lot of time on the ground.

Caterpillar-Ant Relationships

Strangely, no ants came to visit the caterpillar on the *Medicago* species, in captivity, even though it was already excreting a substance at stage L2 that didn’t seem to have any effect.

There were several different kinds of ant inhabiting the area around the caterpillar cage, but none of them were attracted to it. On reaching stage L5 we took it back to Beaujeu on the 19th May. Once it had settled on a leaf rosette of *Medicago* it was joined by an ant *Tapinoma nigerrimum* which had most likely been attracted by the Newcomer’s gland. For the first time we saw the tentacles come out (plate III : 15). The ant became excited and immediately returned to the caterpillar watching over it constantly. Later on a second ant from the same species appeared. On returning at the end of the afternoon we took the caterpillar back into captivity and it seemed agitated. The following days it did not eat, it turned pale yellow and moved about without stopping. Despite our precautions it managed to escape and on the 22nd we found it on the side of a pot surrounded by about ten

Plagiolepsis pygmaea. We captured it again and the ants quickly disappeared. On the 24th, once again the caterpillar escapes and unfortunately we never found it again.

The development of the caterpillars on *Dorycnium hirsutum* was different from those on the *Medicago*. The first caterpillar had already hatched from its egg on the 20th April (plate IV : 1). We don't know the date when this egg was laid. The little caterpillar had some difficulty moving along the velvety leaves of this host plant. Finally it succeeded in burrowing between the leaves. The following days it snacked on the middle of a leaf. Towards the 26th April the other three caterpillars on the *Dorycnium hirsutum* plants had hatched in their turn and were living hidden amongst the leaves.

The conditions on these four plants were comparable in that none of them were in flower. From the 2nd May we could see a stage L2 caterpillar feeding and resting amongst the leaves, with its abdomen pointing outwards, "the red spot" on show, presumably to attract ants which did not react in any way to this behaviour. On returning to Beaujeu on this same day we found a stage L2 caterpillar in zone F, exhibiting the same behaviour on *Dorycnium hirsutum* also not in flower (plate IV : 2). There was a *Tapinoma nigerrimum* ant hill nearby, but no ants seemed to be interested in it. Several days later this plant was eaten by the sheep. The caterpillars on *Dorycnium hirsutum* grew slower than those on *Medicago* species, this could be due to the absence of flowers which contain proteins essential for their growth (Mann, 1999; Cano *et al.*, 2008).

Because the caterpillars on *Dorycnium hirsutum* were significantly slower to develop than those on *Medicago* on 15th May, we decided to move two stage L3 caterpillars from *Dorycnium hirsutum* onto *Medicago polymorpha*. Immediately they began to feed on the flowers. The two stage L4 caterpillars that remained on *Dorycnium hirsutum* were seen for the last time on 27th May (plate IV : 3).

On the 28th May around 7pm on a very cloudy evening, we went in search of caterpillars at Beaujeu. At the edge of the field in zone H we found three stage L5 caterpillars on a flowering *Dorycnium hirsutum* (plate IV : 9), surrounded by *Tapinoma nigerrimum* ants which are the most widespread species found in the fields at Beaujeu (plate IV : 5, 6). The caterpillars were pink like the flowers whilst those on *Medicago* were yellowish. The three caterpillars were located on a single plant next to an

ant hill. The next day we went back there in the early afternoon to film the interaction between the ants and the caterpillars. The weather was cloudy with intermittent, fine drizzle. There were only two caterpillars on the plant of which one was surrounded by *Tapinoma nigerrimum* and the other with large, black ants *Camponotus aethiops* (plate IV: 4). Two *Camponotus aethiops* watched over the caterpillar and two explorative *Tapinoma nigerrimum* waiting trying to chase off the first trespasser without success. Both caterpillars had a strong interaction with the two species of ants. The caterpillars frequently stretched out their tentacle-like organs, provoking a lively reaction from the ants; from time to time the caterpillars emitted a drop from the Newcomer's gland which was immediately collected by an ant and then distributed amongst its fellows (plate IV : 7, 8).

The Chrysalis

We decided to bring back and keep in captivity two full-term caterpillars, so that we would have a chrysalis. In the hope of reproducing as far as possible a natural habitat, an ant's nest of *Tapinoma nigerrimum* was included. By the next day the ants had reorganised their nest in the large terrarium and were busy attending to the two caterpillars. These ones were less active in this last stage than the ones raised on *Medicago* and they didn't change colour. On the 7th June they disappeared. Carefully opening the ants nest, there in the middle we found a caterpillar surrounded by ants. We left the nest alone until the 13th June so as not to disturb the caterpillars. We found a total of three chrysalises at a depth of 2m.

The chrysalises are two shades of brown and transparent enough to be able to see the internal organs inside (plate IV : 11).

Two of them measured 11mm and third one was 10mm. They over-wintered outside under a shelter in a little plastic pot filled with soil. At the start of spring we noticed that two of the chrysalises had paled and not survived the winter. The third one was darker (plate IV : 12). Not until the 29th April at 9.25am did a male hatch which we released the same day back into the wild at Beaujeu (plate IV: 13-15).

Was the late hatching of the chrysalis due to the climatic conditions which in spring 2009 were particularly cold and wet or the fact that hibernation took place outside of the warmth of the ant nest?

The future of *Tomares ballus*

During the last two years the weather conditions have been extreme in the area studied (Beaujeu): hot and dry, or cold and wet. Throughout the world we have witnessed floods or catastrophic drought. On 15th June our region received nearly 400mm of rain in three hours resulting in many deaths and the destruction of urban developments. These extremes also took their toll on nature. In 2009 a wet winter followed by a hard and very wet spring could have had a detrimental effect on the survival of the *Tomares ballus* chrysalises because only 2 butterflies were spotted at Beaujeu.

On the other hand, it's possible that the particularly favourable conditions of winter and spring 2005 may have played a positive role and partly explain the large number of adults observed not only by us at the site but also by Yvan Diringer (2007) and Luc Manil (personal comment) in other habitats in the Var.

In general it is difficult to predict what effect these climatic changes will have on the survival of *Tomares ballus*.

Observations from different authors during the last decade for the whole of the Var are on the whole encouraging for *Tomares ballus*, but with considerable variation from one year to the next (Direnger, 2007 ; Andre Chauliac, Christian Castellain, Luc Manil ; personal comment)

It's logical to think that **global warming** could be beneficial to *Tomares ballus* in the sense that the Var is situated in the northern limit of its distribution and that it is better adapted to very hot dry conditions (North Africa). However the **chaotic nature** of global warming (more extreme weather conditions of all kinds which can sometimes last a long time) could also have a negative effect. Surprisingly the predictions in the *Climate risk Atlas of European Butterflies* (Settle et al., 2008) suggests that the climate in the south of France would be unfavourable for *Tomares ballus* and that an increase in global warming would greatly reduce the number of suitable habitats for this species in Europe. This study does not follow recent statistics (the decade 2000 – 2010) which are altogether more encouraging (Luc Manil ; personal comment).

Another “optimistic” phenomenon for this butterfly was recently described in Spain: since we find a few colonies of this species amid the cultivation

of lentils. This situation could pose problems for the farmers. Measures to overcome the damage caused during the harvest have been put into place (Cano *et al.*, 2008), but the use of pesticides is a threat to the new populations and is a cause for anxiety.

Other factors not involved in this study must play a role, in particular the microclimate.

The moderate grazing by sheep at the beginning of spring and in autumn could have a positive effect on the habitat at Beaujeu (by preventing trees from re-establishing and the invasion of grass). However if during April and May the sheep stay in one place for too long, the effect will be devastating for the survival of the eggs and caterpillars, thus endangering this population. After an intensive period of grazing the droppings left behind encourage the growth of grass resulting in the decline of host plants. But during the last three years the wild boar have become more numerous and turned-over the soil creating suitable places for the host plants to thrive.

However, the biggest threat to *T. ballus* is urban development (Direnger, 2007) and the resulting destruction of the habitat. In the southwest of Beaujeu, at La Motte, the vineyards are taking over the *garrigue*. In the Bandol area it's the construction of second homes that is threatening certain populations. Even though the area south of Callas lies in the **Natura 2000** zone, it seems that this statute does not completely guarantee the protection of the unique, diverse and vulnerable flora and fauna of this region as described in *le guide du naturaliste dans le Var* (Quertier *et al.*, 2002). Perhaps other measures must be taken to avoid the destruction of the best habitats in this region, which accommodate several vulnerable species like *Zerynthia polyxenia*, *Zerynthia rumina*, *Laeosopsis evippus* (= *roborus*), *Callophrys avis*, *Charaxes jasius*, *Apatura ilia*, *Maculinea arion*, *Libythea celtis* and *Pyrgus sidea* (Bence *et al.*, 2009) not forgetting the other less vulnerable butterflies that are present there.

Conclusion

Although *Tomares ballus* is described as being one of the first butterflies of spring in Provence, we have never seen it before the end of March in this habitat even though other butterfly species that over-winter in adult form at Beaujeu fly from the middle of February like *Nymphalis polychloros*, *Inachys io*, *Vanessa atalanta*,

Libythea celtis, *Gonepteryx rhamni*, *G. Cleopatra* and several butterflies that over-winter as chrysalises such as *Colias crocea*, *Pieris napi*, *P. rapae*, *Euchloe crameri*, *Callophryx rubi*, and *Lycaena phlaeas*. *Tomares ballus* was never seen at the site before the first week of April (Comment added by editor: In the Bandol region which is closer to the sea, the butterfly often flies around the 20th March) and every year the males frequented exact locations. We conclude that they probably choose those places which are close to the host plants.

With regard to the courtship flight, it is important to note that all the elements are based on a small population of *Tomares ballus*. It is possible that they would behave differently in larger populations.

The butterfly increases its chance of survival for instance by the females using several kinds of host plant like *Dorycnium pentaphyllum* and *Dorycnium hirsutum* which grow in very diverse situations.

The eggs laid on *Doryniium pentaphyllum* growing in the *garrigue* and protected from the sheep have a greater chance of survival than those laid on *Medicago*. It is possible that the presence of certain particular ants plays a significant role in where the eggs are laid. Because of the distribution of the host plants it is significant that the males and females meet at these well defined locations. The caterpillars are active during the day and according to our observations feed mostly on the flowers and fruits of the host plants; it seems that their appearance is dependent upon the host plant on which they feed. The caterpillars are partially myrmecophilous and possess a Newcomers gland and two small, projectile organs; in addition they are surrounded by ants of at least two species *Tapinoma nigerrimum* and *Camponotis aethiops*. At the second larval stage (L2), we noticed the existence of another secretory gland on the 9th abdominal segment (the red spot). Although the caterpillars don't depend on the ants for their development and their transformation into a chrysalis (Cano *et al.*, 2008), it is highly probable, that in nature, this transformation takes place near or in an anthill. The raised

temperatures (in excess of 25 degrees in spring) due to the constant rebuilding of the *Tapinoma nigerrimum* ant nest could explain in part why this species emerges early in the year. It would be interesting to study in greater depth the interaction between the caterpillars and the ants.

It is highly likely that the population of *Tomares ballus* at Beaujeu is the most easterly in Europe.

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