

Notes on the ♀ genitalia of satyrid butterflies (I): *Hipparchia autonoe* (ESPER, 1783)

(Lepidoptera, Nymphalidae, Satyrinae)

by

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Abstract: In this paper, the ♀ genitalia, more accurately the bursa copulatrix, of palearctic species *Hipparchia autonoe* (ESPER, 1783), including three Chinese subspecies, *H. autonoe extrema* ALPHÉRAKY, 1889 from N. China, *H. autonoe arcellae* SBORDONI, BOZANO & CESARONI, 2018 from Qinghai and *H. autonoe mabcha* MARKHASIOV, 2021 from S.W. Tibet, is studied. The bursa copulatrix of *H. autonoe* (ESP.) is photographed and illustrated in different directions, and its composed elements are annotated in every figures. Nomenclature and hypothetical origin of elements composing the sterigma are reviewed basing upon COUTSIS (1984).

According to COUTSIS (1984), the ♀ genitalia of Ditrysia (Lepidoptera) including butterflies can be divided into two entities, namely the primary genitalia (for egg production, fertilization and laying) and the bursa copulatrix (for sperm reception and temporary storage). The bursa copulatrix is composed of the corpus bursae, the ductus bursae and the sterigma (KLOTS, 1970; COUTSIS, 1984), and its study is not only morphologically useful but also taxonomically valuable. In Satyrinae, the structure of the sterigma is often very complex comparing with many other Ditrysia insects, with its varies elements whose homologies in different satyrid tribes, subtribes and even genera are poorly known. Usually, authors seldom use features of the ♀ genitalia in taxonomic practices, when they deal with generic or specific level classification in Satyrinae. Even in the classic higher classification of the Satyridae by MILLER (1968), the ♀ genitalia as a feature was not used. One possible reason is that enough features from the ♂ genitalia as well as androconia can often be well used as specific diagnoses; another possibility is that researchers abandon these features from the ♀ genitalia simply because of its complex and hardly describable structures. Nonetheless, some related works had still been presented. SHIRÔZU & SHIMA (1979) studied species groups of *Ypthima* HÜBNER, 1818 and used features of the genitalia. COUTSIS (1984) especially studied the ♀ genitalia of the *Hipparchia fagi* SCOPOLI, 1763-group (subgenus *Hipparchia* F., 1807) and the *H. semele* L., 1758-group (subgenus *Parahipparchia* KUDRINA, 1977) (SBORDONI et al., 2018), and prompted a fundamental nomenclatural system for Satyrinae. LANG (2019) studied the ♀ genitalia of the *Paroeneis pumilus* (C. FELDER, 1867)-group and *Aulocera sybillina* (OBERTHÜR, 1890), and in view of their high similarity he ascertained their close relationship and confirmed that *Paroeneis* MOORE, 1893 is only a junior synonym of *Aulocera* BUTLER, 1867 and is even not a bona subgenus. In those species groups and complexes whose ♂ genitalia and androconia are unrecognisable in related species, the successfully utilizing ♀ genitalia features as decisive diagnostic characters is rare, for example, HUANG (2003) established some new species in the *Ypthima newara* MOORE, [1875]-group basing upon the discrepancy of their ♀ genitalia. But in most cases alike, features of the ♀ genitalia can provide few useful diagnoses. WAGENER (1959-1961) studied East Asian *Melanargia* MEIGEN, 1828, and in his research, the ♀ genitalia was involved without any obvious effect. LANG (2020) attempted to use features of the ♀ genitalia in the *Loxerebia saxicola* (OBTH., 1876)-complex, but distinct differences could barely be found. In general, for the ♀ genitalia, distinct structural discrepancies are perfect diagnoses for distinguishing different species; but for a given element, mere variation in shape is possibly not stable even in a species.

The study of the ♀ genitalia of Satyrinae is insufficient, without a systematic study, its true value for classification of Satyrinae can hardly be evaluated, and without a support of homogeneity, its nomenclatural system is also lowly effective. For a named element, is it a homogeneous or an analogous organ? Is it for merely convenient using or for anatomic value? Then, to clarify these, a systematic study is needed. The present author plans to give a series of works on the ♀ genitalia of Satyrinae, and here it is the start of the series. The first reason to begin with *Hipparchia autonoe* (ESP., 1783) is because this species has a perfectly complex ♀ genitalia which can be used as a comparison for the next researches; the second is because COUTSIS (1984) had already studied con-subgeneric *H. fagi* SCOPOLI and related species from Europe and provided a nomenclatural system which includes a lot of invented names for Satyrinae on the cornerstone of Lepidoptera by KLOTS (1970). However, some small modifications and improvements for the system of COUTSIS (1984) are needed, for example, an element should belong to a unit instead of another; in addition, a set of multi-directional photographs of the sterigma as well as some other involved elements can provide a more complete picture of a complex structure which is hardly demonstrated by only a fixed angled drawing.

Materials: In this study, the genitalia of three subspecies of *Hipparchia autonoe* (ESP.) from China are studied, they are *H. autonoe extrema* ALPH., 1889 from Shaanxi and Shanxi, *H. autonoe arcellae* SBORDONI, BOZANO & CESARONI, 2018 from Qinghai and *H. autonoe mabcha* MARKHASIOV, 2021 from S.W. Tibet. Materials are kept in Dr. SONG-YUN LANG's private collection, Beibei, China.

Methods: Treatment and observation of the genitalia follow the methods in COUTSIS (1984). Using a Canon digital camera interlinking an Olympus stereomicroscope, photographs were took for the genitalia, more accurately the bursa copulatrix, from several different directions. If needed, studied parts, units and elements of the bursa copulatrix were dissected and photographed separately. Directions in general include lateral, dorsal, ventral, caudal, and cephalic view (see arrowheads in fig. 2). The direction of caudal view used in this paper is equivalent to "dorsal view" in COUTSIS (1984).

Terminology: Terminology of the genitalia in this paper follows those of KLOTS (1970) and COUTSIS (1984) with some modifications and improvements.

The bursa copulatrix of *Hipparchia autonoe* (ESPER, 1783) (figs: 1-7, 10-11, 13-18) COUTSIS (1984) separated the **bursa copulatrix** (bu. c) into three parts, viz. the **corpus bursae** (crp. bu), the **ductus bursae** (du. bu) and the **sterigma**. The crp. bu and du. bu of *Hipparchia autonoe* (ESP.) are similar to those of its european congeners studied by COUTSIS (1984), therefore, only the sterigma (figs: 1-7, 10-11, 13-17), or called the genital plate by PIERCE (1909) earliest (KLOTS, 1970), is emphasised here. KLOTS (1970) divided the sterigma

“often no sharp distinction between these is possible”. According to WAGENER (1959: 20, Abb. 13), llp (= pvp) and lla (= avp) are the 8th tergite (t8) and the 8th sternite (s8) respectively. However, COUTSIS (1984) wrote that the sterigma “presumably derived from the 8th sternite”, and he believed that it “may be broken down into three basic units: the distal, median and proximal unit” (Table 1). Structurally, the sterigma of *Hipparchia* F. is the most complex even in Satyrinae, and it can hardly be determined whether or not its various elements and those corresponding elements of other satyrid butterflies are homologous organs. Nevertheless, at least for the basic units, their derivations should be consistent in Satyrinae.

In view of the definition of the sterigma (= llp + lla) in KLOTS (1970), it is reasonable that every elements caudad and dorsad of the **ostium bursae** (o. b) belong to the distal unit (= llp) and all elements of the sterigma cephalad and ventrad of the o. b belong to the median unit (= lla). The distal and median units are originated from the 8th sternite, and in *Hipparchia* F. they are fused together with their transitional part forming a post-ostial funnel, which is around the ostium bursae. However, this concept of the distal and median units is different from that of COUTSIS (1984), who regarded both the post-ostial funnel (around o. b) and the ventral lamella (ventrad o. b) as components of the distal unit. In fact, the ventral lamella, which is situating rightly below the ostium bursae and expanding from the lower part of the post-ostial funnel, and the upper flange, which was treated by COUTSIS (1984) as an element of the median unit, are respectively the upper and lower sclerotized tegument of a flattened sac-like process, which is cephalad opening, below the ostium bursae. Thus, this process as a whole should be named as the ventral lamella; and the upper flange can be considered as a secondary name and it is only the lower tegument of the newly integrated ventral lamella. Furthermore, the ventral lamella should be an element of the median unit, or lla, but not be an element of the distal unit as mentioned in COUTSIS (1984). Such processes located below the ostium bursae like a ventral lamella can be widely observed in many satyrids, though their homologies can be not easily confirmed, their function are similar. Moreover, the dorso-lateral lobes of the median unit should be noted: they are a couple of plates sprouting from the base of the lower tegument of the ventral lamella (the upper flange), and forming a bi-lateral frame of the sterigma; their apexes extend upwards towards the 8th tergite (even connected the latter in some satyrids) and often exceed the top of llp. In *Hipparchia* F., the inner edge of the dorso-lateral lobe is well separated from llp by a narrow membrane fissure, but in some other satyrids, it is fused with llp as an integral wall or belt. The third unit of the sterigma, the proximal unit *sensu* COUTSIS (1984), can be clearly separated from the median unit, which belongs to the 8th sternite, by a membrane fissure, thereby, it should be sclerotized elements, including a pair of **lateral arms** and a **ventral tray** (figs: 8, 9), on the intersegmental cuticula between the 7th and 8th sternites (abbreviated as IC7-8S). The proximal unit is neither a part of the bursa copulatrix nor a part of the sterigma, and just like the 8th tergite (fig: 12) or something others, it is independent from the genitalia system.

Accordingly, as above mentioned, the sterigma derived from the 8th sternite is divided into two parts as llp and lla. Certainly, terms like llp and lla are more suitable for those simply structured sterigma, but for a more complicated construction, it is better for considering it as two units (Table 2): the **posterior unit** (= llp), including a **mid-dorsal process** and a pair of **dorsal lamellae**; and the **anterior unit** (= lla), including a pair of **dorso-lateral lobes**, a **ventral lamella** with its lower tegument (named as **upper flange**) connected with a **lower flange** by a vertical **web** in middle. Meanwhile, the **post-ostial funnel** around the ostium bursae is a transitional and anastomosing area between the posterior and anterior units (llp/lla). Consequently, the terms, the distal unit and the median unit in COUTSIS (1984), are replaced by more accurate terms, viz. the posterior unit and the anterior unit respectively; and the term, the proximal unit in COUTSIS (1984), which equals the IC7-8S, is abandoned.

The sterigmas in different subspecies of *Hipparchia autonoe* (Esp.) are uniformly built in structure, but for some elements, individual and inter-subspecific variations in shape can be found. Size of the sterigma of *H. a. mabcha* MARKHASIOV is only half as large as sizes of *H. a. extrema* ALPH. and *H. a. arcellae* SBORDONI et al., surely, it is a positive correlation with their butterflies' body sizes. The dorsal lamellae of *H. a. mabcha* MARKHASIOV are relatively smaller than those of *H. a. extrema* ALPH. and *H. a. arcellae* SBORDONI et al. The mid-dorsal process with its distal end is more protruding in some individuals, but less in others. The ventral lamella is widened with its lateral edges heavily bending downwards in *H. a. extrema* ALPH. and *H. a. arcellae* SBORDONI et al., whereas it is narrower with lateral sides moderately bending downwards in *H. a. mabcha* MARKHASIOV. The lower flange (fig: 18) is variable, its tip is acute or round in *H. a. extrema* ALPH.; it is broad in *H. a. extrema* ALPH. and *H. a. arcellae* SBORDONI et al., whereas it is slender in *H. a. mabcha* MARKHASIOV. Btw, for the ventral tray (not an element of the sterigma now) of *H. a. extrema* ALPH., individual discrepancy caused by different sclerotized degree can be observed (figs: 9a, 9b). Finally, it can be deduced that for some elements their variations in shape are results of sub-speciation, for example, some discrepancies between *H. a. mabcha* MARKHASIOV and *H. a. extrema* ALPH.; for some others, they are only individual variations. Therefore, in the future practices, the using of different sizes or even shapes of a given element from the genitalia as a diagnostic character should be carefully considered.

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Part	Unit	Element
sterigma (= 8th sternite)	distal unit	mid-dorsal process
		dorsal lamella
		post-ostial funnel
		ventral lamella
	median unit	upper flange
		web
		lower flange
		dorso-lateral lobe
	proximal unit	ventral tray
		lateral arm

Table 1: Division and terminology of sterigma in COUTSIS (1984).

Part	Unit	Element
sterigma (= 8th sternite)	posterior unit (= 1lp)	mid-dorsal process
		dorsal lamella
	sclerotized transitional zone	post-ostial funnel
	anterior unit (= 1la)	ventral lamella
		upper flange
		web
		lower flange
IC7-8 (intersegmental cuticula of 7th-8th abdominal segments)	IC7-8S (intersegmental cuticula of 7th-8th sternites)	dorso-lateral lobe
		ventral tray
		lateral arm

Table 2: Division and terminology of sterigma + IC7-8 in this paper, all names of the sclerotized elements following COUTSIS (1984).

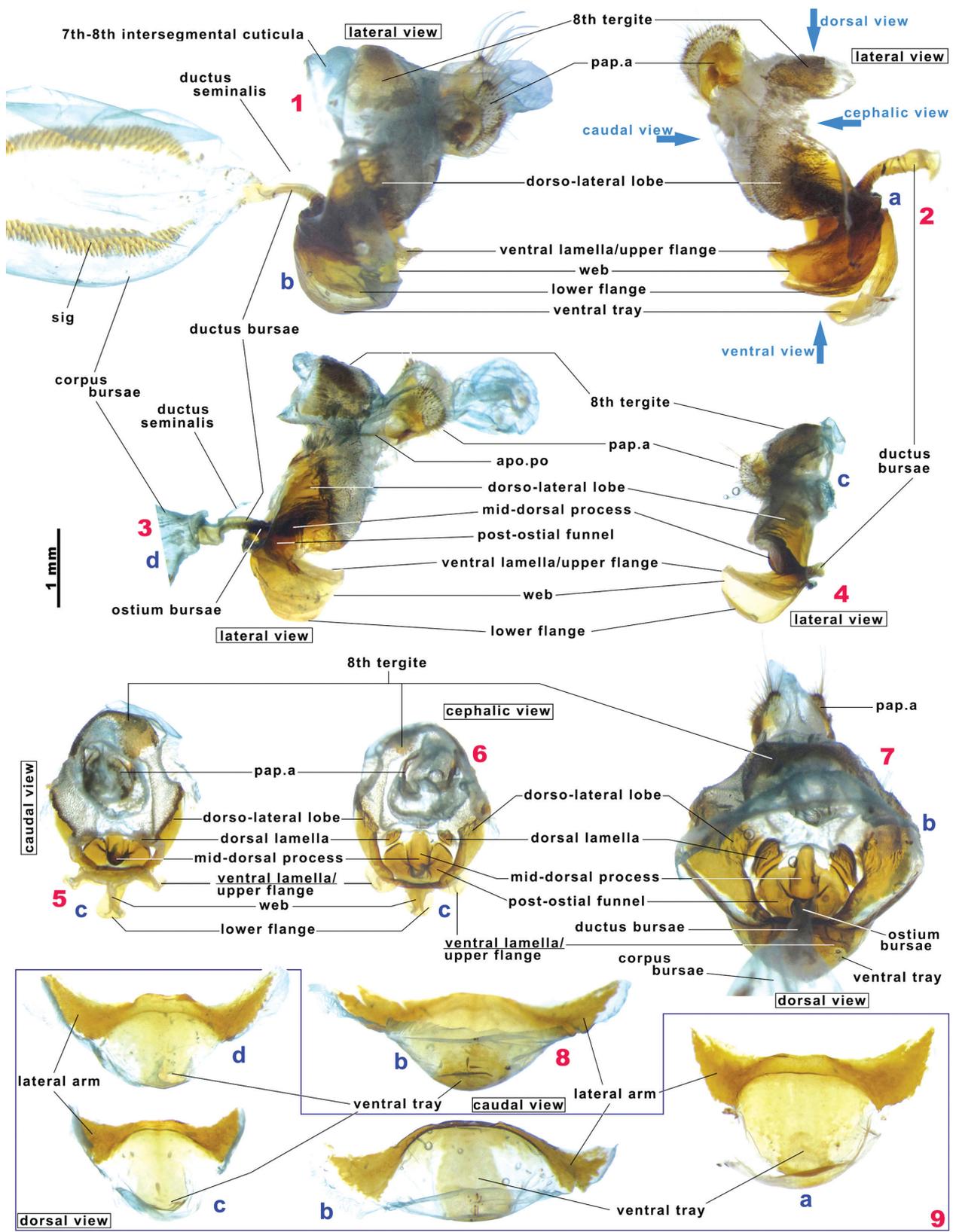


Fig. 1-9: ♀ genitalia. - **a:** *Hipparchia autonoe extrema* ALPH., Shaanxi, Qingjian, SATY0782; **b:** *H. autonoe extrema* ALPH., Shanxi, Qinyuan, SATY1168; **c:** *H. autonoe mabcha* MARKHASIOV, Tibet, Burang, SATY1169; **d:** *H. autonoe arcellae* SBORDONI et al., Qinghai, Ulan, SATY1170. - **Fig. 1:** bursa copulatrix + IC7-8S + t8 + pap. a, in lateral view; **Fig. 2:** sterigma + du. bu + IC7-8S + t8 + pap. a, in lateral view; **Fig. 3:** sterigma + du. bu + t8 + pap. a, in lateral view; **Fig. 4:** sterigma + t8 + pap. a, in lateral view; **Fig. 5:** ditto, in caudal view; **Fig. 6:** ditto, in cephalic view; **Fig. 7:** sterigma + du. bu + IC7-8S + t8 + pap. a, in dorsal view; **Fig. 8:** IC7-8S, in caudal view; **Fig. 9:** ditto, in dorsal view.

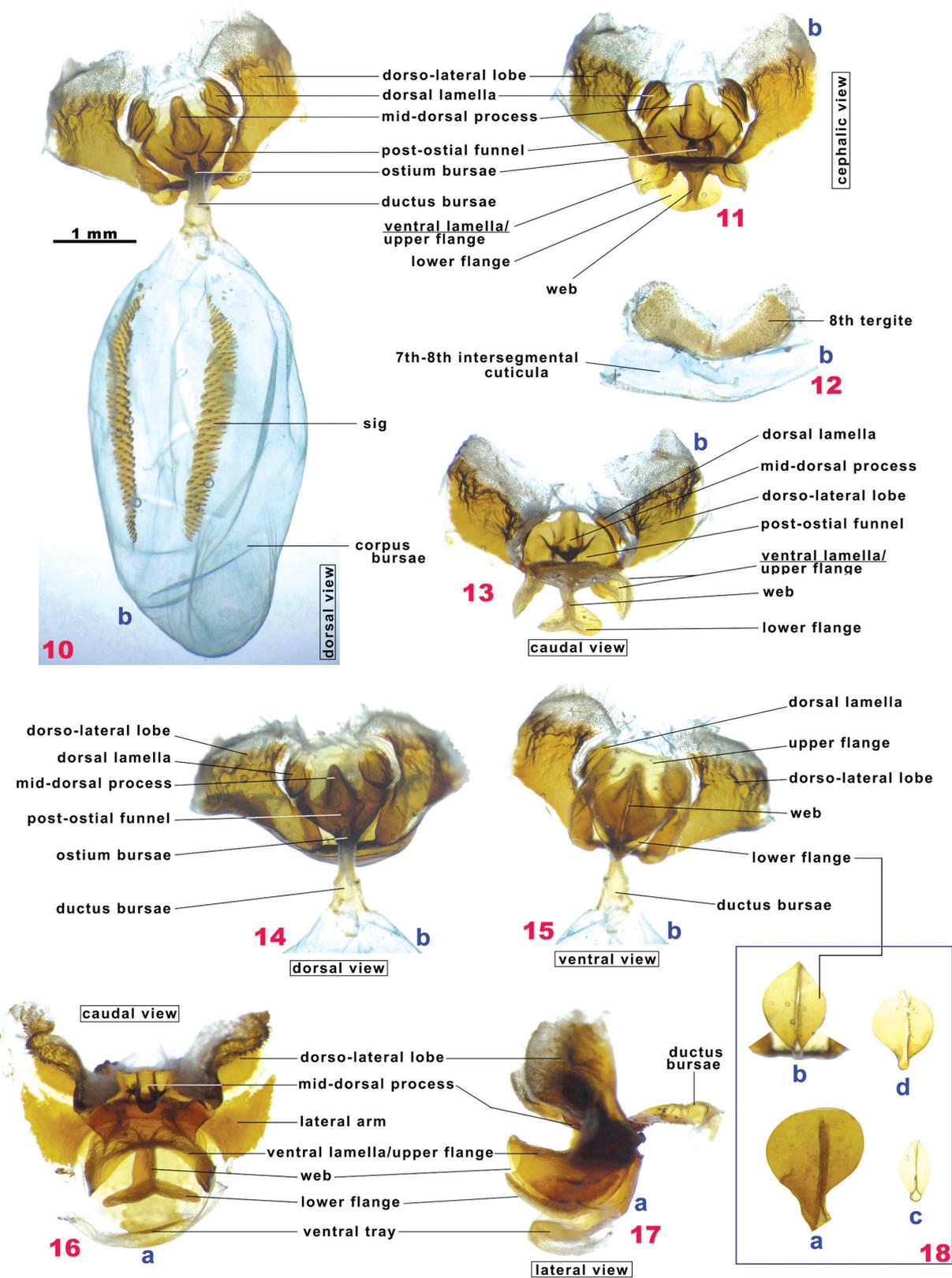


Fig. 10-18: ♀ genitalia. - **a:** *Hipparchia autonoe extrema* ALPH., Shaanxi, Qingjian, SATY0782; **b:** *H. autonoe extrema* ALPH., Shanxi, Qinyuan, SATY1168; **c:** *H. autonoe mabcha* MARKHASIOV, Tibet, Burang, SATY1169; **d:** *H. autonoe arcellae* SBORDONI et al., Qinghai, Ulan, SATY1170. - **Fig. 10:** bursa copulatrix, in dorsal view; **Fig. 11:** sterigma, in cephalic view; **Fig. 12:** t8, in dorsal view; **Fig. 13:** sterigma, in caudal view; **Fig. 14:** bursa copulatrix with crp. bu removed, in dorsal view; **Fig. 15:** ditto, in ventral view; **Fig. 16:** sterigma + IC7-8S, in caudal view; **Fig. 17:** ditto, in lateral view; **Fig. 18:** lower flange.

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