

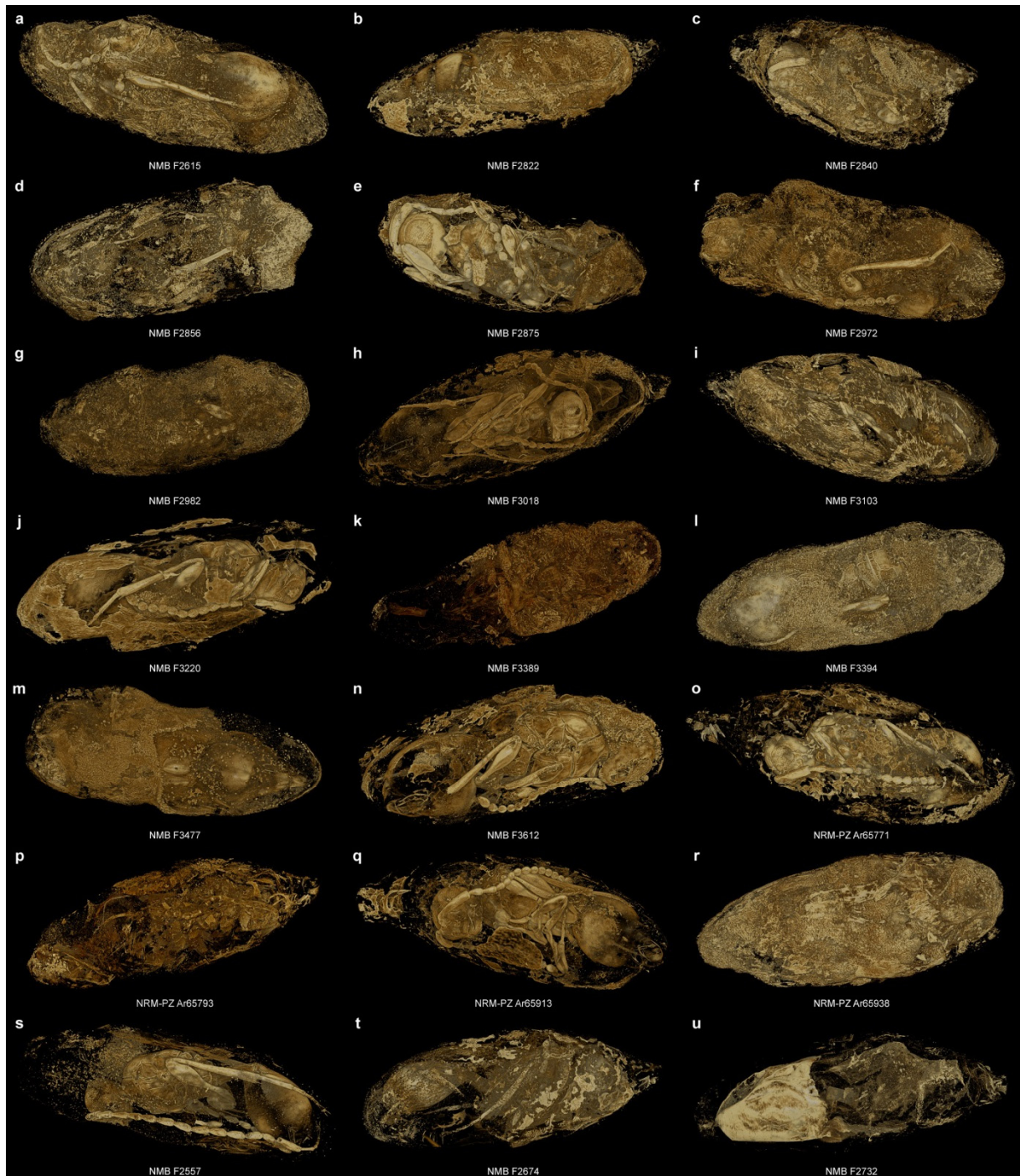
Supplementary Information

Parasitoid biology preserved in mineralized fossils

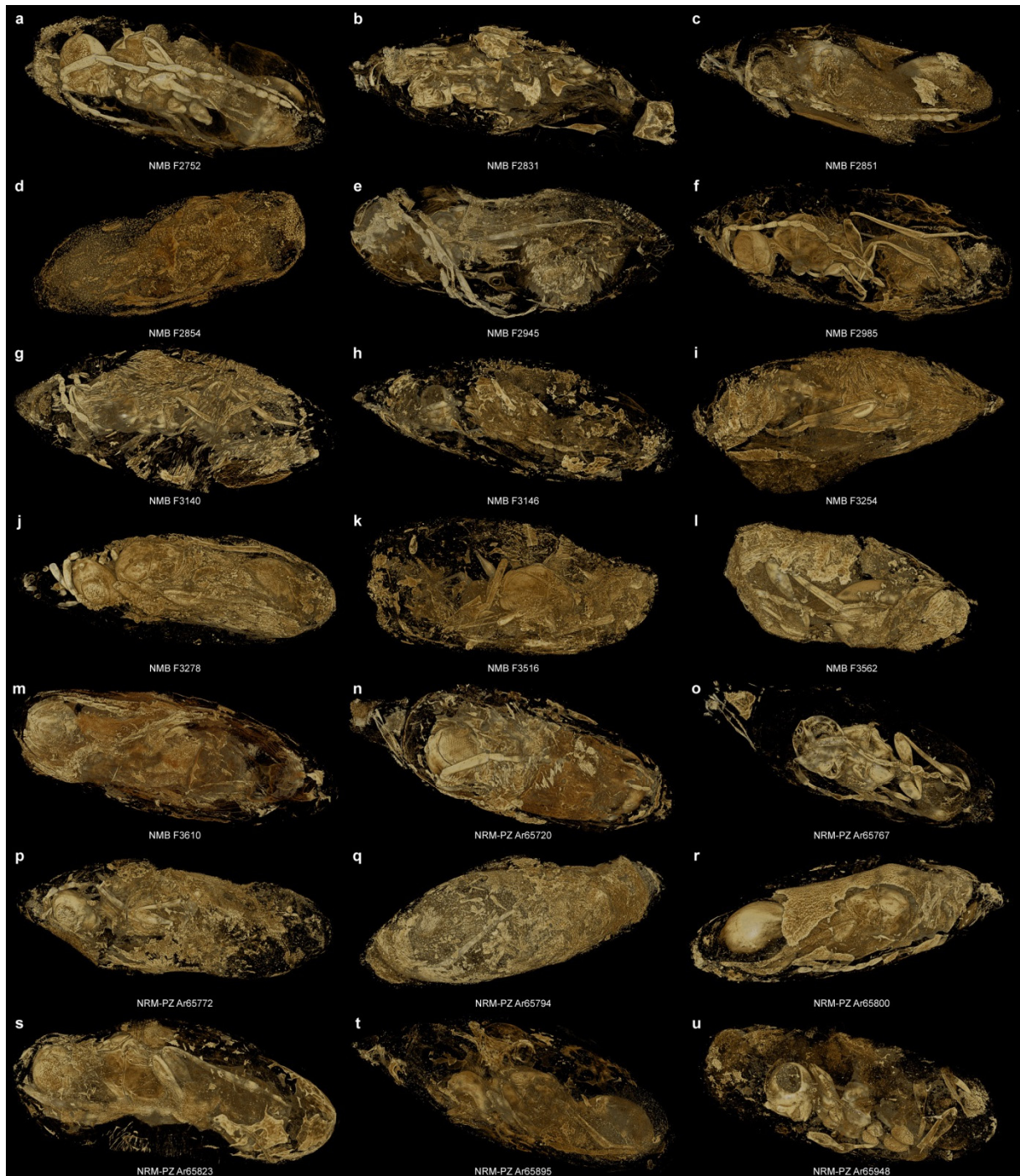
van de Kamp *et al.*



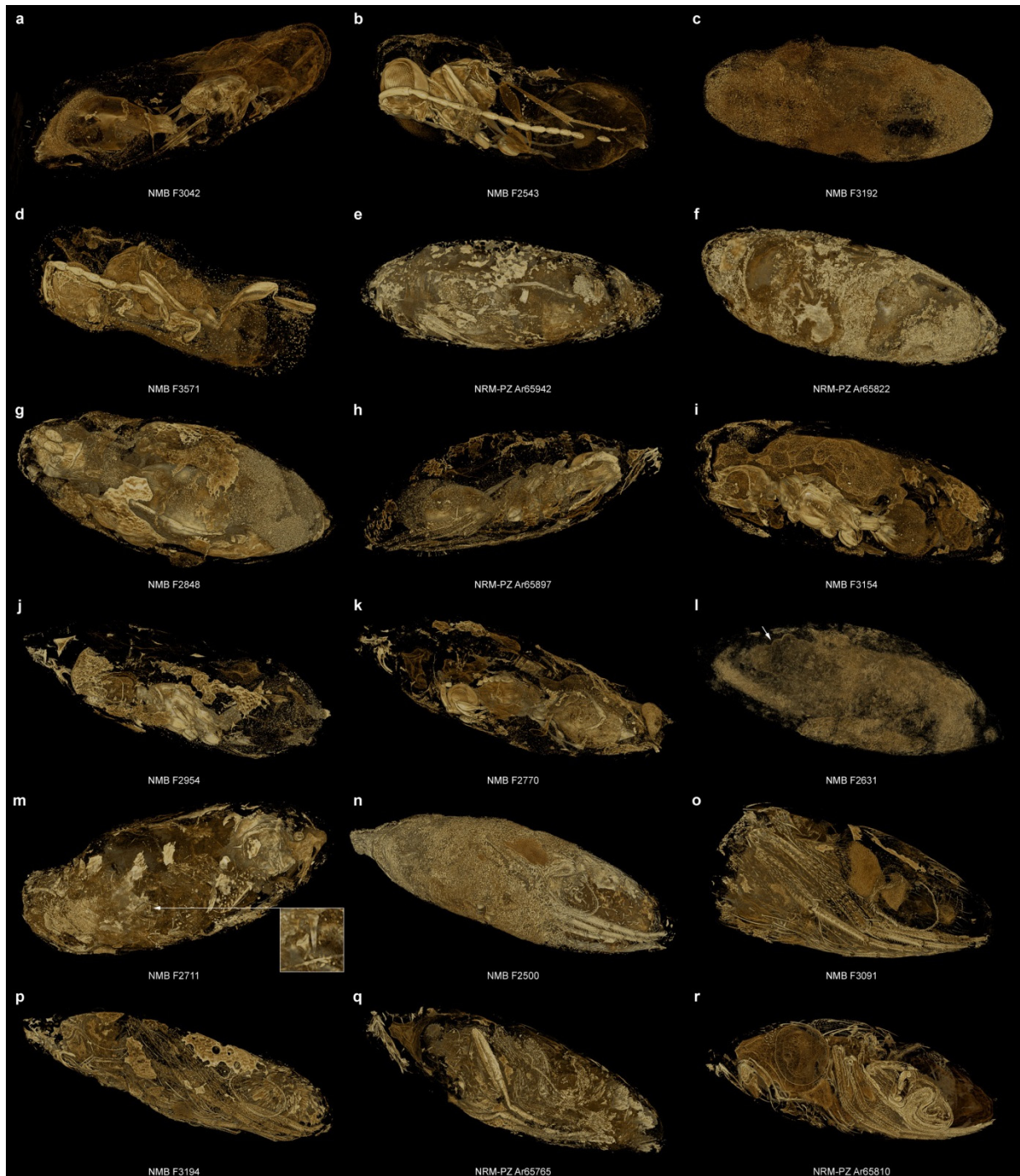
Supplementary Figure 1 | Photographs of the fossils, in which the following parasitization events or host remains were identified: a-r: *Xenomorphia resurrecta* females; s-ap: *X. resurrecta* males; aq: *X. handschini* female; ar-au: *X. handschini* males; av: *X. handschini* pupa of unknown sex; aw-ay: *Coptera anka* females; az: *C. anka* male; ba: *Palaeortona quercyensis* female; bb: unidentified putative second instar larva; bc: last-instar larval mandibles left-behind by an emerged parasitoid; bd-bh: preserved parts of the host flies. Scale bar: 1 mm.



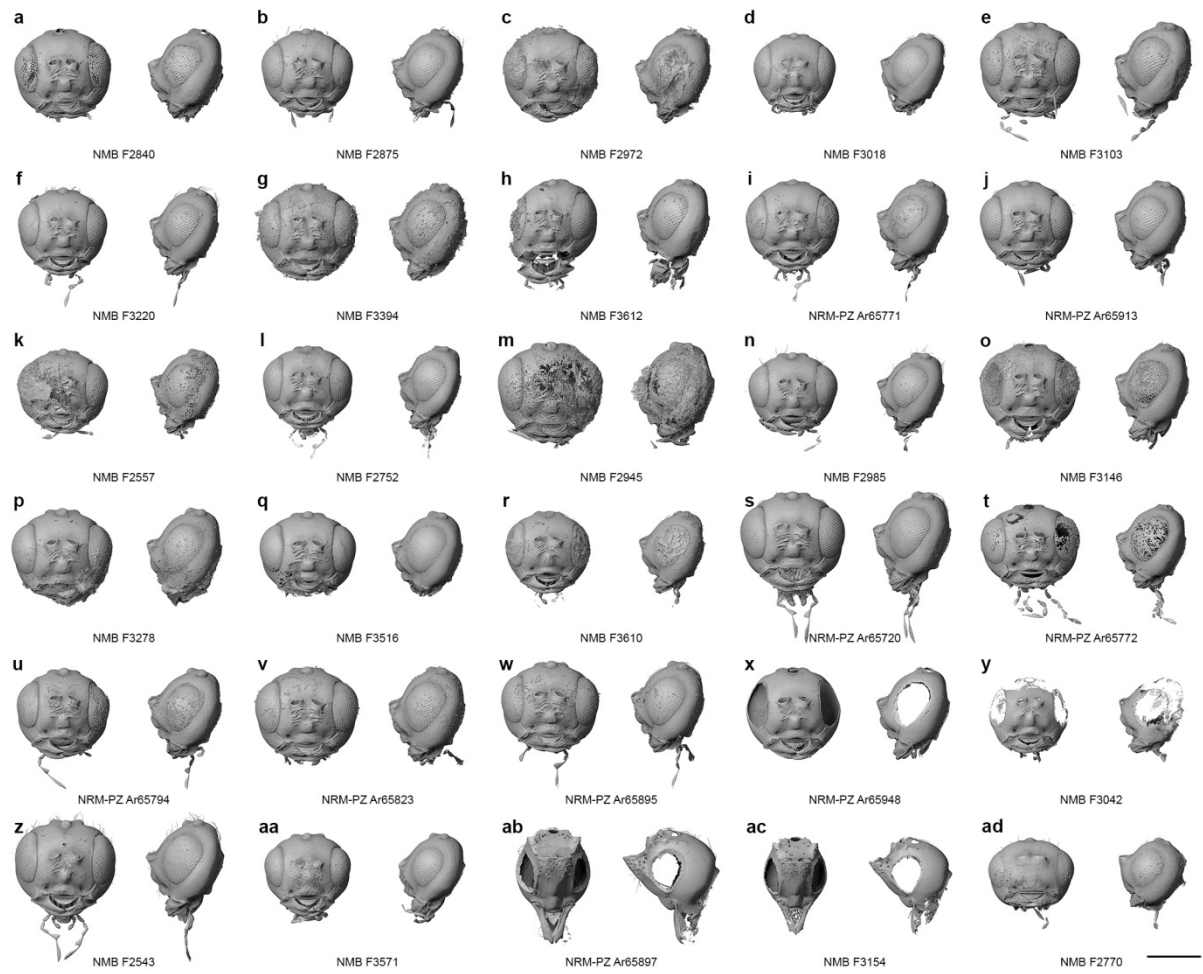
Supplementary Figure 2 | Volume renderings of the inside of *Eophora* pupae, in which parasitism events were identified (perspective view). a-r: *Xenomorphia resurrecta* females; s-u: *X. resurrecta* males. See Supplementary Fig. 1 for external shape of the puparia and scale bar.



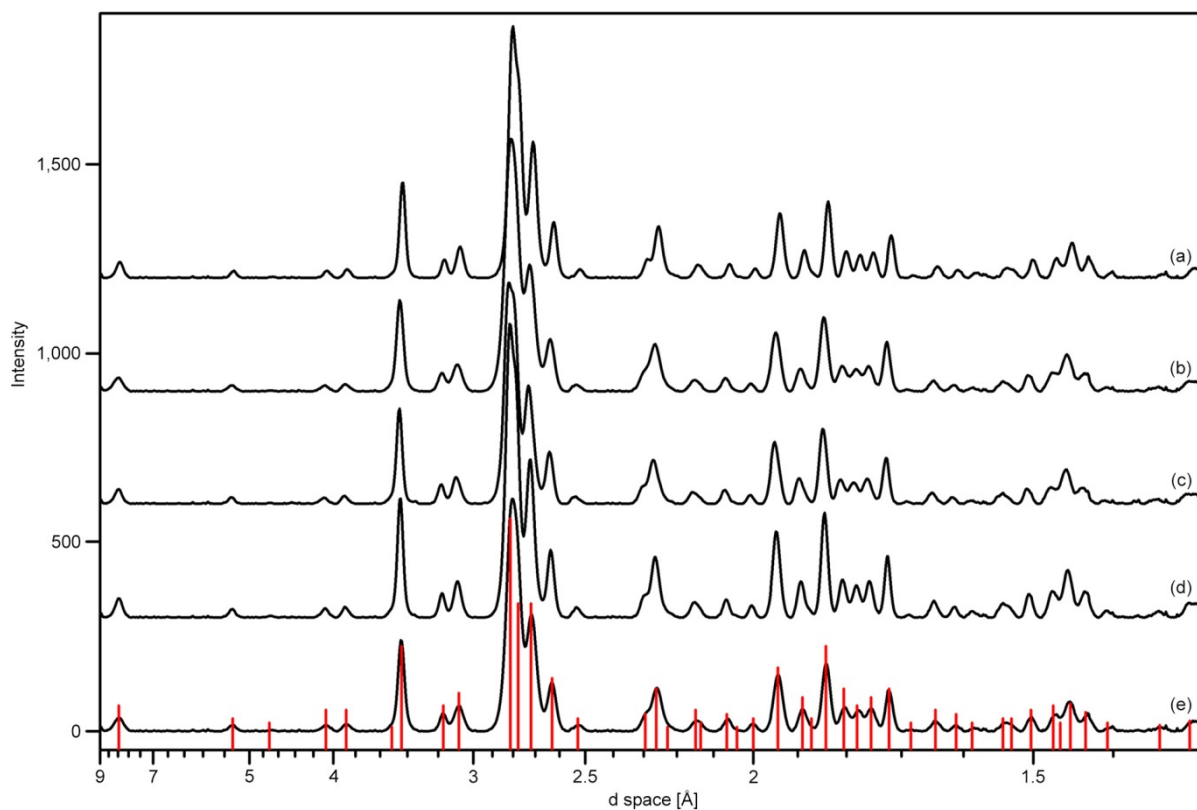
Supplementary Figure 3 | Volume renderings of the inside of *Ephora* pupae, in which parasitization events were identified (*Xenomorphia resurrecta* males; perspective view). See Supplementary Fig. 1 for external shape of the puparia and scale bar.



Supplementary Figure 4 | Volume renderings (perspective view) of the inside of *Eophora* pupae, in which parasitisation events or host remains were identified (perspective view). a: *Xenomorphia handschini* female; b-e: *X. handschini* males; f: *X. handschini* pupa of unknown sex; g-i: *C. anka* females; note the preserved fly host legs in (h); j: *C. anka* male; k: *Palaeortona quercyensis* female; l: unidentified putative second instar larva (arrow); m: last-instar larval mandibles left-behind by an emerged parasitoid (see inset); n-r: preserved parts of the host flies. See Supplementary Fig. 1 for external shape of the puparia and scale bar.



Supplementary Figure 5 | Surface renderings of 30 parasitoid heads. a-j: *Xenomorphia resurrecta* females; k-x: *X. resurrecta* males; y: *X. handschini* female; z,aa: *X. handschini* males; ab: *Coptera anka* female; ac: *C. anka* male; ad: *Palaeortona quercyensis* female. Scale bar: 250 μ m.



Supplementary Figure 6 | Synchrotron X-ray diffraction pattern of five pupae. NMB F2459 (a), NMB F2460 (b), NMB F2531 (c), NMB F2557 (d) & NMB F2915 (e). All samples consist of the mineral apatite (general formula $\text{Ca}_5(\text{PO}_4)_3(\text{OH},\text{F},\text{Cl})$), indicated by a line pattern from the ICDD database (entry PDF 9-432).

Supplementary Table 1 | List of identified parasitiation events

collection no.	species	sex	stage	posture	wings	reference length (µm)	external preservation of the host	preservation of the parasitoid
NMB F2615	<i>X. resurrecta</i>	female	adult	asymmetric	unfolded	911	pupal skin only	generally well-preserved; mesosoma damaged dorsally
NMB F2822	<i>X. resurrecta</i>	female	adult	symmetric	folded	785	puparium largely detached from pupal skin	generally well-preserved; head hollow
NMB F2840	<i>X. resurrecta</i>	female	adult	symmetric	folded	826	posterior half of puparium missing	generally well-preserved and hollow; posterior part of gaster missing
NMB F2856	<i>X. resurrecta</i>	female	adult	asymmetric	unfolded	790	pupal skin only; antenna shines through	generally poorly preserved; head damaged
NMB F2875	<i>X. resurrecta</i>	female	adult	asymmetric	unfolded	824	pupal skin only	well-preserved; remnants of flight muscles visible
NMB F2972	<i>X. resurrecta</i>	female	adult	symmetric	unfolded	890	pupal skin only	generally well-preserved; head and legs partly damaged
NMB F2982	<i>X. resurrecta</i>	female	adult	asymmetric	unfolded	851	puparium largely detached from pupal skin	generally poorly preserved and partly connected to adjacent voids; head capsule damaged
NMB F3018	<i>X. resurrecta</i>	female	adult	asymmetric	unfolded	765	complete puparium; slightly damaged	well-preserved; antennae and legs largely hollow
NMB F3103	<i>X. resurrecta</i>	female	adult	asymmetric	unfolded	941	complete puparium; small piece of stony matrix attached	generally well-preserved; head capsule hollow
NMB F3220	<i>X. resurrecta</i>	female	adult	symmetric	folded	772	pupal skin only	well-preserved; head capsule largely hollow
NMB F3389	<i>X. resurrecta</i>	female	adult	symmetric	not preserved	779	pupal skin only; damaged	generally poorly preserved; head and gaster deformed
NMB F3394	<i>X. resurrecta</i>	female	adult	asymmetric	not preserved	934	pupal skin only	generally well-preserved but partly connected to adjacent voids
NMB F3477	<i>X. resurrecta</i>	female	adult	?	not preserved	817	puparium largely detached from pupal skin; anterior part missing	poorly preserved and partly connected to adjacent voids; head missing; gaster deformed
NMB F3612	<i>X. resurrecta</i>	female	adult	asymmetric	unfolded	847	pupal skin only; slightly damaged	generally well-preserved; head, mesopectus, gaster and legs slightly damaged
NRM-PZ Ar65771	<i>X. resurrecta</i>	female	adult	symmetric	folded	813	complete puparium	well-preserved; head capsule largely hollow
NRM-PZ Ar65793	<i>X. resurrecta</i>	female	adult	?	not preserved	895	puparium partly detached from pupal skin	generally poorly preserved; petiole barely recognizable; gaster deformed
NRM-PZ Ar65913	<i>X. resurrecta</i>	female	adult	asymmetric	unfolded	824	puparium slightly damaged and posteriorly detached from pupal skin	well-preserved; petiole hollow
NRM-PZ Ar65938	<i>X. resurrecta</i>	female	adult	asymmetric	not preserved	938	puparium posteriorly detached from pupal skin; pieces of stony matrix attached	poorly preserved and partly connected to adjacent voids
NMB F2557	<i>X. resurrecta</i>	male	adult	symmetric	folded	836	pupal skin only	generally well-preserved; head hollow and damaged anteriorly
NMB F2674	<i>X. resurrecta</i>	male	adult	asymmetric	unfolded	857	puparium posteriorly detached from pupal skin	generally poorly preserved; legs of host fly partly visible
NMB F2732	<i>X. resurrecta</i>	male	adult	?	not preserved	835	complete puparium	generally poorly preserved and heavily deformed; petiole distinct
NMB F2752	<i>X. resurrecta</i>	male	adult	asymmetric	folded	765	puparium largely detached from pupal skin	generally well-preserved; left profemur deformed; left antenna broken; remnants of flight muscles visible
NMB F2831	<i>X. resurrecta</i>	male	adult	symmetric	folded	811	puparium partly detached from pupal skin	poorly preserved; head and gaster deformed
NMB F2851	<i>X. resurrecta</i>	male	adult	symmetric	folded	763	puparium anteriorly detached; antenna of parasitoid visible through pupal skin	head barely recognizable; mesonotum well-preserved; mesopectus barely recognizable; petiole well-preserved; gaster deformed
NMB F2854	<i>X. resurrecta</i>	male	adult	?	not preserved	901	pupal skin only	poorly preserved and hardly traceable
NMB F2945	<i>X. resurrecta</i>	male	adult	asymmetric	unfolded	943	pupal skin only; anteriorly damaged	generally well-preserved; head detached; mesosoma and petiole well-preserved; gaster barely recognizable
NMB F2985	<i>X. resurrecta</i>	male	adult	asymmetric	unfolded	774	pupal skin only	generally well-preserved; left antenna broken; left metatibia detached
NMB F3140	<i>X. resurrecta</i>	male	adult	asymmetric	unfolded	816	complete puparium	generally well-preserved; head capsule barely recognizable; several antennal segments and left mesofemur detached
NMB F3146	<i>X. resurrecta</i>	male	adult	symmetric	folded	871	complete puparium	generally poorly preserved and partly connected to adjacent voids; head detached; compound eyes barely recognizable; posterior mesosoma poorly preserved
NMB F3254	<i>X. resurrecta</i>	male	adult	symmetric	folded	804	complete puparium; small piece of stony matrix attached	generally well-preserved but partly connected to adjacent voids; compound eyes barely

NMB F3278	<i>X. resurrecta</i>	male	adult	asymmetric	unfolded	894	puparium partly damaged; small piece of stony matrix attached	recognizable generally well-preserved; several antennal segments detached
NMB F3516	<i>X. resurrecta</i>	male	adult	?	not preserved	n/a	puparium damaged anteriorly and posteriorly; endocast of parasitoid's gaster visible	generally well-preserved but collapsed into pieces
NMB F3562	<i>X. resurrecta</i>	male	adult	symmetric	folded	n/a	puparium heavily damaged; anterior part missing	generally poorly preserved; head and anterior mesosoma missing; ventrally damaged
NMB F3610	<i>X. resurrecta</i>	male	adult	symmetric	folded	761	puparium partly detached from pupal skin	generally well-preserved; gaster damaged dorsally
NRM-PZ Ar65720	<i>X. resurrecta</i>	male	adult	symmetric	folded	911	complete puparium; posterior top slightly damaged	well-preserved; head hollow
NRM-PZ Ar65767	<i>X. resurrecta</i>	male	adult	symmetric	folded	832	complete puparium	generally poorly preserved; head deformed; compound eyes missing; legs and metapetal-propodeal complex hardly recognizable
NRM-PZ Ar65772	<i>X. resurrecta</i>	male	adult	asymmetric	unfolded	777	puparium partly detached from pupal skin; endocast of the parasitoid's gaster visible	generally well-preserved but partly connected to adjacent voids; antennae and legs partly collapsed
NRM-PZ Ar65794	<i>X. resurrecta</i>	male	adult	asymmetric	unfolded	871	puparium damaged	poorly preserved and partly connected to adjacent voids; head hollow
NRM-PZ Ar65800	<i>X. resurrecta</i>	male	adult	symmetric	folded	786	complete puparium with posteriorly damaged surface	generally well-preserved; head barely recognizable
NRM-PZ Ar65823	<i>X. resurrecta</i>	male	adult	asymmetric	unfolded	896	pupal skin only	well-preserved; head, mesosoma and petiole hollow
NRM-PZ Ar65895	<i>X. resurrecta</i>	male	adult	symmetric	folded	782	complete puparium; circular anteroventral damage	generally well-preserved but partly connected to adjacent voids
NRM-PZ Ar65948	<i>X. resurrecta</i>	male	adult	asymmetric	not preserved	856	pupal skin only	generally well-preserved; compound eyes missing; parts of mesosoma barely recognizable; gaster damaged
NMB F3042	<i>X. handschini</i>	female	adult	symmetric	folded	734	pupal skin only; right antenna and procoxae visible	mandibles, dorsal mesosoma and petiole well-preserved; ventral mesosoma barely recognizable; gaster poorly preserved
NMB F2543	<i>X. handschini</i>	male	adult	symmetric	folded	911	pupal skin only; left antenna visible	head and anterior mesosoma well-preserved; posterior mesosoma barely recognizable; petiole and gaster poorly preserved
NMB F3192	<i>X. handschini</i>	male	adult	?	not preserved	n/a	pupal skin only	generally poorly preserved and largely connected to adjacent voids; petiole and parts of mesosoma well recognizable; remnants of flight muscles visible
NMB F3571	<i>X. handschini</i>	male	adult	asymmetric	unfolded	817	pupal skin only; posterior third missing	generally well-preserved; petiole and gaster hollow; antennae and legs partly deformed; posterior part of gaster missing
NRM-PZ Ar65942	<i>X. handschini</i>	male	adult	asymmetric	not preserved	n/a	puparium; damaged anteriorly	generally poorly preserved; only some body parts recognizable (e.g. head capsule, petiole, gaster)
NRM-PZ Ar65822	<i>X. handschini</i>	unknown	pupa	n/a	n/a	n/a	puparium; damaged anteriorly	poorly preserved and deformed; largely connected to adjacent voids; species identification based on broad petiole
NMB F2848	<i>C. anka</i>	female	adult	asymmetric	unfolded	794	pupal skin only	head and anterior mesosoma apparently cut off; otherwise well-preserved
NMB F2954	<i>C. anka</i>	female	adult	symmetric	folded	703	complete puparium; slightly dented	head poorly preserved; compound eyes missing; mesosoma and petiole well-preserved, gaster poorly preserved; distal parts of antennae and legs barely recognizable
NRM-PZ Ar65897	<i>C. anka</i>	female	adult	symmetric	folded	717	complete puparium; dented; fly legs visible	generally well-preserved; compound eyes missing; distal parts of antennae and legs barely recognizable; legs of host fly partly visible
NMB F3154	<i>C. anka</i>	male	adult	symmetric	not preserved	652	pupal skin only	generally well-preserved; compound eyes missing; distal parts of antennae and legs barely recognizable
NMB F2770	<i>P. quercyensis</i>	female	adult	asymmetric	unfolded	810	complete puparium; dented and slightly damaged	generally well-preserved; only some antennal segments missing
NMB F2631	unknown	unknown	putative 2nd instar larva	n/a	n/a	n/a	complete puparium	preserved as void; fine details like mandibles and hairs missing
NMB F2711	unknown	unknown	larval mandibles	n/a	n/a	n/a	pupal skin and minor parts of puparium	only mandibles of last larval instar