Reviewer 3

Sudersan and co-authors have submitted an interesting manuscript on the

understanding of underwater adhesion seen in terrestrial insects with hairy

pads. So far, it remains unclear if an air bubble is necessary for adhesion and

its contribution to the net adhesion force, if any.

They present a nice experimental setup and results about the adhesion force of

individual pads of a ladybug beetle in air and underwater conditions. The

experiments were carried out on smooth hydrophilic and hydrophobic glass

surfaces. The overall experimental details and protocol are described well in

details.

In general, the manuscript reports a quite-well documented Literature and the

experiments were well defined and carefully conducted. The work also includes

good statistical treatments of results.

To my opinion, this paper does meet the standards of the Journal of

Experimental Biology after addressing the following questions (along the

manuscript) in order to improve the manuscript before being published:

• The authors detailed well the adhesion of the attachment system onto

smooth hydrophilic and hydrophobic glass surfaces. Could they comment on the

potential role of substrate topography?

• End of §2.1.1, the authors stated that the beetles were freed after

experiments by “carefully removing the epoxy glue (…)”. How was this done? Is

the epoxy not touching the insect but only the Blu Tack? Please clear out this

part.

• Beginning of §2.1.2, the beam deflection has been calibrated using

different known weights. Could those weights be mentioned and commented with

regards to the insect’s weight range?

• In the experimental section on adhesion test: There is no mention of

applied pre-load to measure the adhesion force values. Only the mention “a

slight compression” appears in §2.1.2, resulting from the z-piezo depicted in

fig. 1. Could author mention the pre-load value and how will it affect the

adhesion force characteristics?

• The contact area from the plot of inset down right in the fig. 1 seems

not to come back to zero at the end of the experiment. Could the authors

explain this issue?

• Authors mention about a short pause (1 s) after contact formation to

remove any viscoelastic effects. Why pause lasts for 1 s? How did the authors

ensure this time was enough for materials viscous relaxation?

• In order to achieve the underwater no bubble experiments, the water was

degassed in a vacuum chamber prior to tests. Although the in-situ contact

pictures in fig. 3, supported by the videos, seems quite obvious, could the

authors comment why this experimental protocol ensure that no air is trapped in

the contact?

• The contacting material is viscoelastic, as mentioned by author.

Therefore, the motion speed should greatly affect the pull-off adhesion

response. The manuscript mentions only 1 contacting/retraction speed. Did

author also study the speed response on adhesion?

• In results (§2.2): authors show the results of adhesion force measured.

Could authors also comment on the behaviour of force-distance curve during the

pull-off cycle? Is this retraction cycle behaviour different for each

contacting conditions?

• Moreover, since the experimental setup includes a nice in-situ

visualisation, couldn’t it be interesting to describe the kinetic of detachment

of the contact (continuous detachment from the outer- to the inner-part of the

contact, Instant snap-out of the contact,…?) as can be investigate in the

videos?

• I suggest that the authors chose other colours in the plot from fig. 2

which may lead to a higher contrast in grey scale so that the plot

understanding, regardless the media.

• Page 10 line 4: a “.” sign misses before “The substrate’s wetting

towards (…)”

• Figure 3a. Hairs are making contact in air mode as shown on right

image. Here one can note two different types of grey scale values (dark and

bright spots) at real contact junctions. Could author comment on this and

specify the real contacting points here?

• Young-Duprè equation mentioned in §3.1 should be written Young-Dupré.

• Please consider replacing “w.r.t.” acronyms by “with respect to”.

(twice in page 15)

• “The contact area fraction of the hairs relative to the pad, α =

NDh2/Dp2, hair aspect ratio, L/Dh, and fluid size parameter, φf , were fixed to

values typical for a ladybug’s hairy pad.” Could the authors provide a

corresponding reference from literature?

• I suggest the authors mention in the text that the §3.2 corresponds to

modeling results obtained in air.

• In Figure 5: the force-distance curve for different contacting

conditions are shown. Could the authors comment on the deviation from zero,

above or below zero line for large distance? In an ideal situation it should

reach back to zero force.

• In the theoretical analysis of contact: no parameter to consider the

mechanical properties of hairs are implemented? Wouldn’t it be useful to

consider it in your model?

• During the underwater (no bubble situation): I believe there might be

another layer in between hair, and substrate, apart from the adhesive fluid.

How do you make sure that the intermediate water layer is completely squeezed

out from the contact interface (between adhesive fluid and substrate)?

• Since the work deals with adhesion depending on (notably) wettability

situation, a reference to the Cassie-Baxter/Wenzel wetting modes could to my

opinion strengthen the context of discussion. For instance, discussing the

imbibition situation vs the literature criteria ([J. Bico et al. Europhys.

Lett. 2001, 55, 214−220] for spontaneous wetting of structured surfaces for

instance) shall make sense when considering the bubble’s role.

• In this respect the value of L (height of cylindrical rods) as been

largely ignored in the modelling / discussion. Actually, rods’ aspect ratio has

been extensively investigated in literature (for both adhesion and

wettability). Could this point be addressed, maybe in further work, or at least

commented or pointed out in this work? Addressing such questions might leads to

some scale effect (like in [V. Hisler et al., Langmuir 2014, 30, 9378−9383])

which might emphasize the application of the results of this work in broader

scale range.