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Temperament of Ethiopian honeybees

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Abstract
Information on the relative defensive behavior variations of Ethiopian bees and factors associated with temperament variation is not available. The objective of this study was to identify the temperament conditions of these honeybee populations. Two hundred forty farmer beekeepers from 57 localities were interviewed based on pre-structured questionnaire to determine aggressive behavior of Ethiopian honeybees, seasons and factors responsible for heightening their aggressiveness. The aggression rate of Ethiopian honeybee groups were determined for 3001 honeybee colonies and analyzed using Kruskal-wallis ANOVA. The aggressiveness varies among honeybee groups. *Apis mellifera jemenitica* honeybees are highly aggressive while *Apis mellifera monticolla* honeybees are relatively docile. The seasons of the year in which aggressiveness enhanced also vary both within and between honeybee groups depending on climatic conditions of their respective areas. The aggression generally heightens when nectar and pollen are abundantly available which is associated with honey flow and harvest and brooding periods. Attacks of enemies are also found the primary factor enhancing the aggression behavior across all honeybee groups. Aggression rate is significant and positively correlated with temperature and negatively with altitude. Generally lowland and southern region honeybees are more aggressive than highlands and northern region honeybees.

Keywords: Aggressiveness; Ethiopia; Honeybees; Races; Seasons

1 Introduction

Tropical African honeybees are generally considered as highly defensive, which is believed to have arisen due to selection pressures of extreme predators and disturbance in their ecology. However, in some areas of tropical Africa, beekeeping can be done without protective clothes (Clauss, 1983), while in some other areas the bees are reported to be swift and violent. Moreover, the presence of variations in aggressiveness among different races of tropical African honeybees and its associations with genetic variations have often been reported (Chandler, 1976;; Hepburn and Radloff, 1998). Collins *et al.* (1989) demonstrated the presence of significant variations in sting alarm pheromone levels between genetically and behaviorally different honeybees and the existence of inter and intercolonial variations in aggressiveness among different honeybee populations.

Besides, the genetic factor, temperament is also influenced largely by climate. Temperature is considered the most important environmental factor that lowers the threshold responses of bees and hence honeybees believed to be more aggressive in hot and low altitude areas than cool and higher altitude (Corner, 1985). On other hand the same species of honeybee, *A. m. jemenitica,* is reported to be docile in very hot North Oman and North Yemen, but aggressive in Sudan and in Chad (Rashad and El-Sarrag, 1980; Field, 1980). Moreover, variations in aggressiveness of bees within apiary and

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its association with colony size, seasonal variation and within time of a day with the changes of weather have also been reported (Hepburn and Radloff, 1998).

Five distinct morphoclusters or races, *A. m. jemenitica, A. m. scutellata, A. m. bandasii, A. m. monticola* and *A. m. woyi-gambella* occur in Ethiopia (Amssalu *et al.,* 2004) (Figure 1). Information on the relative defensive behavior variations of these bees and factors associated with temperament variation is not available for Ethiopia. In this result the temperament conditions of these honeybee populations is conveyed.

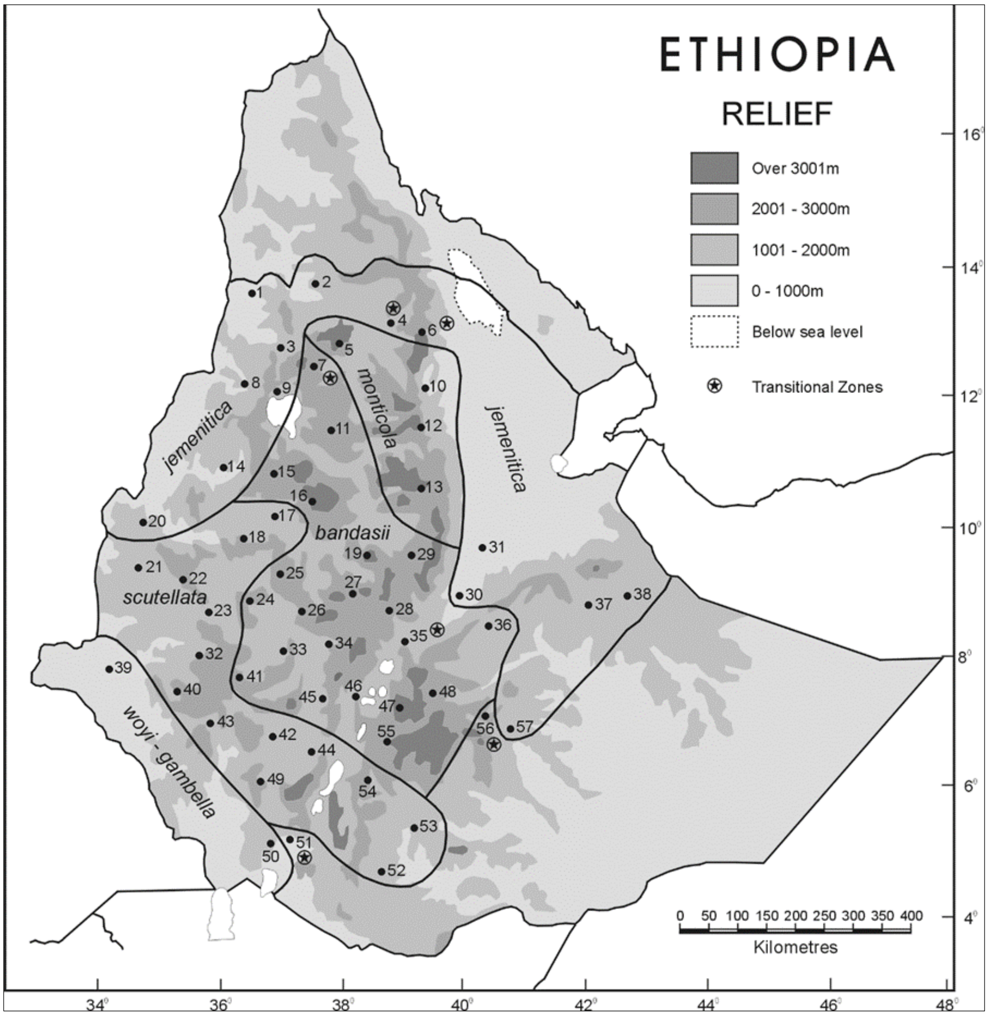


Figure 1 Sampling localities and distribution of five Ethiopian honeybee groups

2 Material and methods

Fifty seven localities were selected as representative of the different major ecological areas in Ethiopia (Figure 1). The localities, altitudes and geographical co-ordinates are shown in Table 1. At each locality an average of about 4 experienced beekeepers and bee technicians (total 240) were interviewed based on a pre-structured questionnaire. Aggressiveness of honeybee populations was assessed for 3001 honeybee colonies based on beekeepers' responses to the following different temperament conditions of bees.

- The proportion of colonies that were reported as aggressive to the total number of colonies owned by interviewed beekeepers was recorded and compared among morphoclusters.
- Qualitative evaluations like docile, aggressive and very aggressive relative terms were used to categorize and compare the degree of temperaments of colonies in the different morphoclusters.
- The temperament condition of the bees in relation to color and factors attributable for the aggressiveness of honeybees were recorded & compared.

- Seasons of a year at which bees become more aggressive and the relationships of ecological factors like rainfall, altitude and temperature with temperament condition of bees for each locality were compiled and analyzed.

Table 1 Localities, altitudes and co-ordinates of study areas in Ethiopia (refer to map in fig. 1)

S.N	Locations	Altitude	Latitude	Longitude	S.N	Locations	Altitude	Latitude	Longitude
1	Humera	600m	14.17N	36.36E	30.	Melka Sedi	770m	9.15N	40.07E
2	Shiraro	1100m	14.19N	37.43E	31.	Gewane	587m	9.58N	40.32E
3	Angereb	910m	13.13N	37.08E	32.	Gechi	1516m	8.21N	35.51E
4	Abi Adi	1800m	13.37N	38.59E	33.	Boter Bacho	2958m	8.21N	37.16E
5	Debark	3000m	13.23N	39.30E	34.	Roge	2194m	8.30N	37.59E
6	Mekele	2025m	13.23N	39.30E	35.	Nazrieth	1699m	8.32N	39.17E
7	Dabat	2656m	12.59N	37.43E	36.	Boke Tiko	1575m	8.43N	40.38E
8	Wohni	1000m	12.39N	36.41E	37.	Deriri Arba	1450m	9.79N	42.23E
9	Aykel	2230m	12.32N	37.03E	38.	Dudi Affi	1559m	9.12N	42.57E
10	Korem	2600m	12.34N	39.32E	39.	Itang	456m	8.11N	34.16E
11	Debre Tabor	2450m	11.54N	37.57E	40.	Masha	2110m	7.46N	35.28E
12	Woldeya	2400m	11.53N	39.26E	41.	Effo Yachi	1877m	7.57N	36.30E
13	Guguftu	3600m	10.55N	39.27E	42.	Waka	1719m	7.44N	37.11E
14	Manbuk	1230m	11.17N	36.14E	43.	Woshi	1750m	7.19N	36.12E
15	Dangila	2060m	11.12N	36.51E	44.	Sodo	1759m	6.49N	37.43E
16	Feres Bet	3000m	10.46N	37.38E	45.	Hosaina	2276m	7.33N	37.53E
17	Bir Sheleko	1545m	10.33N	37.10E	46.	Alage	1830m	7.36N	38.24E
18	Hinde	2195m	10.08N	36.27E	47.	Mararo	2869m	7.24N	39.14E
19	Salayish	2248m	9.50N	38.54E	48.	Gado Lama	2121m	7.40N	39.46E
20	Menge	1000m	10.22N	34.45E	49.	Sawla	2087m	6.18N	36.52E
21	Bambis	1460m	9.44N	34.43E	50.	Woyito	921m	5.16N	37.33E
22	Nejo	1890m	9.30N	35.29E	51.	Konso	1436m	5.20N	37.25E
23	Dedessa	1320m	9.01N	36.01E	52.	Arero	1483m	4.49N	38.52E
24	Nekemte	2166m	9.05N	36.33E	53.	Har Kalo	1427m	5.33N	39.23E
25	Shambu	2570m	9.00N	37.27E	54.	Eshido Aliyo	2158m	6.17N	38.39E
26	Gedo	2517m	9.00N	37.27E	55.	Serofta	2377m	6.51N	39.15E
27	Inchini	2650m	9.20N	38.21E	56.	Woltae Atote	2051m	7.15N	40.34E
28	Sendafa	2500m	9.04N	38.54E	57.	Karre Tule	1194m	7.34N	41.45E
29	Deneba	2670m	9.47N	39.12E					

2.1 Statistical analyses

Tests of normality and homogeneity of the variances of the data were performed using Kolmogorov-Smirnov and Levene's methods respectively. The proportion of aggressiveness of honeybees was analyzed using non-parametric Kruskal-Wallis ANOVA procedure. To detect whether statistically significant differences occurred, Mann-Whiteny U test was used. The P-value of significance was taken using the Bonferroni's adjustment $\alpha = 0.05/K$ to the level of significance for multiple comparisons, where K is the number of paired comparisons. For categorical data, the Chi-square test with

Yates' correction for low frequencies was applied. Correlation analysis was carried out to investigate the relationships between the aggressiveness conditions and environmental factors.

3 Results

The result indicates the percentage proportion of highly aggressive honeybee population in Ethiopia varies from 10% to 71.3% with an average of 46%. Significant variation in aggression behavior was observed among the five Ethiopian honeybee groups (H (4, N = 225) = 106.29; P < 0.000001) (Table 2). *A. m. jemenitica* honeybees are highly significantly aggressive than *A. m. scutellata*, *A. m. bandasii* and *A. m. monticola* (P < 0.00001). No significant differences were observed between *A. m. jemenitica* and *A. m. woyi-gambella* in one hand and between *A. m. scutellata* and *A. m. bandasii* in other hand (P > 0.005) (Table 3).

Table 2 The proportion of highly aggression rates of Ethiopian honeybee groups

Honeybee groups	Total number of colony	Number of highly aggressive honeybee colonies	Proportion of highly aggressive colonies (%)
A. m. jemenitica	668	476	71.3
A. m. scutellata	1348	620	46
A. m. bandasii	744	264	35.5
A. m. monticola	212	21	10
A. m. woyi-gambella	29	11	37.9
Total	3001	1392	46.4

(H (N = 225) = 106.29; P < 0.000001)

Table 3 Pair-wise comparisons (mann-whiteny U test) of aggression rates among the five honeybee groups of Ethiopia

Honeybee groups	*A.m jemenitica*	*A.m scutellata*	*A.m bandasii*	*A.m monticola*	*A.m Woyi-gambella*
A. m, jemenitica		0.000001	0.000001	0.000001	0.0072
A, m, scutellata	0.000001		0.01432	0.000001	0.72213
A. m. bandasii	0.000001	0.01432		0.000001	0.88339
A. m. monticola	0.000001	0.000001	0.000001		0.00195
A. m. Woyi-gambella	0.0072	0.72213	0.88337	0.00195	

The significant level adjusted using Bonferroni procedure. That is, significant if P < 0.05/10 = 0.005

A .m. woyi-gambella is significantly different only from *A. m. monticola*. On other hand *A. m. monticola* honeybees are significantly less aggressive than all other honeybee groups (*A. m. jemenitica, A. m. scutellata, A. m. bandasii* and *A. m. woyi-gambella*), P < 0.005) (Table 3). The proportion of highly aggressive honeybee population in descending order are: 71.3% for *A. m. jemenitica*, 46% for *A. m. scutellata*, 37.9% for *A. m. woyi-gambella*, 35.5% for *A. m. bandasi*i and 10% for *A. m. monticola* (Table 2). Yellow honeybees are more aggressive than the black honeybees (Yates chi X^2 (4) =14.96; P < 0.005). This holds true for all honeybee groups except for the population of *A. m. woyi-gambella,* in which, the blacks are more aggressive (Table 4).

Four conditions, heightening the aggression behavior of Ethiopian honeybee were identified. These are honey flow, honey harvesting, and brood rearing periods and attacks of pests and predators. However the importance of these factors across the honeybee groups are different. *A. m. jemenitica*, *A. m. scutellata*, *A. m. bandasii*, and *A. m. woyi-gambella* become more aggressive than usual during honey flow and honey harvesting periods while, *A. m. monticolla* show no change of aggression behavior during these period (Yates chi X^2 (4) = 23.14; P <0.0002 and (4) = 54; P < 0.0000001 respectively, Table 5). On the other hand all honeybee groups become more aggressive during attacks of pests and predators and brood rearing times (Table 5).

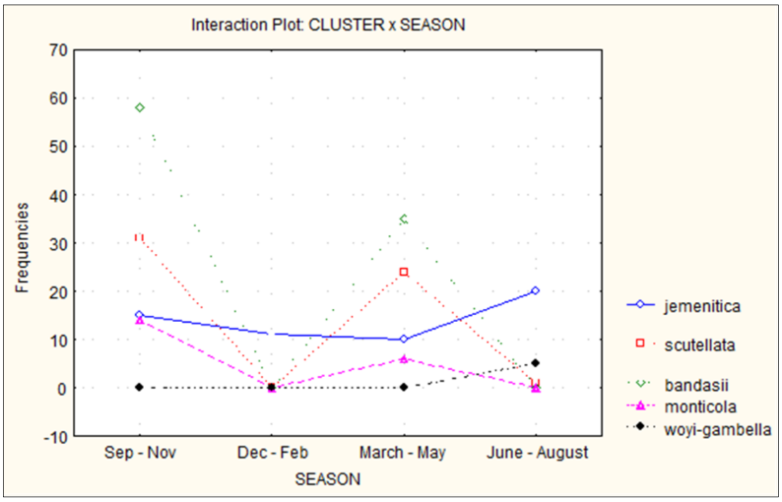
Table 4 Aggressive behavior of Ethiopian honeybees by color as evaluated by farmer beekeepers

Honeybee groups	Sample size	Yellow	Black
A. m. jemenitica	56	62.6	37.5
A. m. scutellata	56	60.78	39.22
A. m. bandasii	92	83.82	16.18
A. m. woyi-gambella	5	20	80
Total(n)	209	68.89	31.11

Yates chi-square (4) = 14.96; P = 0.0048; **NB** data for *A. m. monticola* was not included as black and yellow honeybee colonies were not found together in the same apiary

Table 5 Conditions aggravating the aggression behavior of honeybees (numbers are the responses of farmer beekeepers in percentage, 0 = against, 1 = in favor and n is number of sample units in respective areas of honeybee groups)

Conditions	***A.m jemenitica* n = 56**		***A.m scutellata* n = 56**		***A.m bandasii* n = 93**		***A.m monticola* n =93**		***A.m Woyi-gambella* n =5**		**Yates chi-square**
	0	1	0	1	0	1	0	1	0	1	
Honey flow	35.93	66.10	17.86	82.14	32.26	67.74	75	25	0	100	P = 0.00012
Honey harvesting	16.07	83.93	10.71	89.29	23.66	76.34	90	10	0	100	P< 0.000001
Brooding	32.14	67.86	17.86	82.14	13.98	86.02	10	90	0	100	P = 0.061
Pests and predators	0	100	16.07	83.93	30.11	69.89	0	100	40	60	P = 0.00002



Yates chi- square (12) = 98.76; P < 0.0000001

Figure 2 Seasonal aggressiveness of Ethiopian honeybee groups

The aggression behavior of Ethiopian honeybees varies from season to season. The season in which aggression is heightens was highly significantly different both within and between honeybee groups (Yates chi X^2 (12) =171.60; P < 000001). In *A. m. jemenitica* honeybee population, aggression heightens during June through August and September through November. Like in *A. m. jemenitica,* aggression is biphasic in the *A. m. monticola, A. m. scutellata* and *A. m. bandasii* and occurs during September through November and March through May. But in *A. m. woyi-gambella* honeybee group aggression mainly heighten during June through August (Fig. 2).

Aggression behavior of honeybees is significantly and negatively correlated with altitude ($r = -0.60$; $P < 0.0001$) and rainfall ($r = -0.17$; $P = 0.01$) and positively correlated with temperature ($r = 0.58$; $P < 0.0001$).

4 Discussion

About 46% of Ethiopian honeybee populations are highly aggressive this implies that, they are easily irritated, fierce and attack immediately. Hive operation is only possible after sunset at dusk. Between 1999 and 2000 the deaths of 6 people and number of domestic animals were reported due to stings in different sampling localities of southern Ethiopian region. This is a common feature in Africa. Many people and animals are killed by sting of African honeybees (El-Sarrag, 1977). For example between 1961 and 1967 the deaths of 24 people and sever stung of 8 people due to reaction of being stung were reported in South Africa (Ordman, 1968; Star, 1977) and 5 oxen stung to death in Botswana (Edmundy, 1931). In general African honeybees are highly defensive due to African climate supports the occurrence of number of factors that stimulate the aggressive behavior of honeybees.

There were considerable variations in aggressiveness among the five Ethiopian honeybee groups. These interracial variations in aggressiveness in tropical Africa honeybee colonies were reported in different parts of Africa (Chandler, 1976; Hepburn and Radloff, 1998; Kempff Mercado, 1973; Peled, 1971). *A. m. jemenitica* honeybees are the most aggressive of all other honeybee groups of Ethiopia and followed by *A. m. scutellata*, *A. m. woyi-gambella* and *A. m. bandasii*. While the northern highland honeybees, *A. m. monticola* is relatively docile. *A. m. jemenitica* honeybees mainly occupy the lowland areas from southern eastern through north to northwest which is characterized by semi-arid ecology and high temperatures. Moreover in northern western areas of this honeybee group, honeybees are kept in the forest. On other hand *A. m. monticola* occupy the highlands between 2400 and 3600 m.a.s.l and beekeeping is mainly practiced at backyard. Thus these may explain why *A. m. jemenitica* and *A. m. monticola* are the most aggressive and docile honeybees respectively in Ethiopia. Even though *A. m. jemenitica* in northern Oman and Yemen are reported docile, these honeybees are very aggressive in Sudan and Chad (Ruttner, 1988; Rashad and El-Sarrag, 1980; Dutton et al., 1980; Field, 1980). On other hand *A. m. monticola* is docile and can easily be worked without protective clothing and even with no smoke (Hepburn and Radloff, 1998). Honeybees in northern parts of Ethiopia are less aggressive than the southern ones. This could be due to the fact that, the northern honeybee colonies are kept at backyards and near the living houses with the people and domestic animals. In same places of the northern part of the country, honeybee colonies are sold in open market, where a lot of people are found. This shows that the northern honeybees are relatively tame.

On the other hand beekeeping in the southern areas is practiced mainly in the forest as the result honeybees exhibit wildness and high defensive behavior. The ecology of the northern areas of the country is more highland than the southern parts. It is also common to find very aggressive and very docile honeybee colonies in the same apiary in Ethiopia. This agrees with Hepburn and Radloff (1998). The variation in aggressiveness within and between honeybee groups may attribute to the amount of sting pheromone, colony strength, environmental conditions and genetically (Collins et al., 1989, Hepburn and Radloff, 1998).

Yellow or lighter honeybee colonies are more aggressive than the black or darker honeybee colonies. This may be associated with temperature: The higher temperature the lighter honeybees and the more aggressive in behavior. However this cannot be generalized, as some exceptions are exist. I.e. black honeybee colonies in the western and southern lowlands (*A. m. woyi-gambella* areas) are reported more aggressive than the lighter ones.

Brood rearing period and pest and predator attacks were noted as one of the major factors heightening the aggression across all honeybee groups. This could be due to the fact that aggression behavior of honeybees generally seems closely associated with the flowering periods and subsequent brood rearing and colony strength. I.e. brood rearing increases the proportion of gourd bees or defensive forces. This is in agreement with the results of Hepburn and Radloff, (1998) who noted the association of aggressiveness with colony size. On the other hand pest and predators are stimulating defensive behavior. This observation is in agreement with the reports of Smith (1958) and Clauss (1984) who noted that the level of aggressiveness increases by an attempt from predation ranging from beekeeping operation to internal robbing.

Unlike the other honeybee groups, in *A. m. monticola* honeybee group the association between aggressiveness and honey flow and honey harvest periods were found low, which could be due to the relative gentleness of these honeybees and careful handling of honeybee colonies by beekeepers during honey harvesting. The gentleness and manageability of *A. m. monticola* as European honeybees were well documented (Smith, 1961; Ruttner, 1988; Dietz et al., 1986; Hepburn and Radloff, 1998).

Time of the year in which aggression behavior of honeybees heightens correspond to time of the year at which ample of forage is available in their respective areas. This could vary both within and between honeybee groups depending on the climatic conditions of the area they occupy. The highest aggressiveness is always associated with strong nectar flow and intense foraging because abundant pollen and nectar permit colonies to become extremely populous, which in turn increases the number of honeybee for colony defense. The level of aggressiveness varies from colony to colony, group to group and over seasons.

Aggression is significantly positively correlated with temperature and negatively with altitude. This implies that lowland honeybees are more aggressive than the highland honeybees. This may be attributed to the higher temperature in lowlands. High temperature increases the level of aggression by lowering the threshold of responses and this correlation of aggression with temperature is also evident even within groups.

Generally the aggression behavior of honeybees associated with environmental factors, genetic, the strength of the colonies, the large store, and amount of alarm pheromone produced (Chandler, 1976) and poor handling of honeybees. Besides high reproductive swarming and migration rates, the pronounced aggressiveness, in Ethiopian in particular and Africa honeybees in general seems strategy for survival.

5 Conclusion

According to the study, aggression disparities between and within groups were present in Ethiopian honeybees, and these differences were exacerbated by a variety of circumstances. Beekeeping practices are one of the elements that heighten aggressive behavior, among other things: honeybees raised in the forest are wild and more aggressive, whereas honeybees kept in backyards are domesticated and substantially less aggressive. Therefore this is the opportunity to improve the aggression behavior of Ethiopian bees either through long term selection or switching from forest to backyard beekeeping that allows careful management of honeybees and the protect honeybee colonies against annoyances that encourage hostility.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest.

Statement of informed consent

All authors agreed on the publication of this paper and assigned corresponding author responsible in responsibility for correspondence during manuscript publishing.

Author's contribution

Amssalu Bezabeh: contributed in research conceptualization, experimental design, data collection and data curation, analysis, and final writing of manuscript.

Esubalew Shitaneh: contributed in technical and management advice, final draft of manuscript writing.

Emana Getu: contributed in proof reading, editing the manuscript.

Availability of data and material

Data is available with the corresponding author upon request.

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