Zagovor morfometrične analize koščenih konic

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Izvleček

Prispevek je odgovor na kritiko morfometrične analize koščenih konic zgodnjega mlajšega paleolitka. Podani so tudi nekateri novi rezultati, ki se tičejo tipologije in stratigrafsko podprtih razvojnih teženj koščenih in drugih konic v slovenskih paleolitskih najdiščih.

Ključne besede: orinjasjen, koščene konice, tipologija, razvoj

Abstract

The paper is an answer to the criticism of morphometric analysis of Early Upper Palaeolithic bone points. New results on the typology and stratigraphicaly supported evolutionary trends of bone and other points from Slovene palaeolithic sites are presented.

Keywords: Aurignacian, bone points, typology, evolution

Temeljno idejo, tj. kompletno metodologijo za klasifikacijo koščenih konic, prikazano v članku "Morfometrična analiza zgodnjih koščenih konic v povezavi z najdbami koščenih konic iz Divjih bab I" (Turk 2002), je kritika označila za zgrešeno (Brodar 2003). Pri tem ni bila mišljena statistična metoda kot taka, ampak njena uporaba v danem primeru. Zato je bila kritika usmerjena tudi na določitev mer koščenih konic, češ da so nenatančne in subjektivne. Če je to res, so resnični tako trditev o zgrešenosti nove metode za opredeljevanje koščenih konic kot posledično tudi rezultati, ki jih takšna metoda omogoča. Moja dolžnost je, da v dobrobit stroke pokažem, da je ta kritika neupravičena in po mojem zgolj plod nerazumevanja osnovnih principov statistične metode. Druge kritične pripombe nimajo takšne teže, zato se z njimi ne bom podrobneje ukvarjal.

Večkrat sem že poudaril, da je v raziskovalnem delu ključna metoda.To velja tudi za tipologijo koščenih konic, ki je bila predmet številnih razprav. Dobra metoda lahko kljub nenatančnim (sumarnim) podatkom pripelje do cilja, slaba ali nikakršna metoda pa kljub še tako natančnim podatkom in natančnemu delu pa nikoli .

Pri analizi gradiva za domnevno sporni članek sem izhajal prav iz tega. Zato sem mere koščenih konic, ki doslej niso bile nikjer objavljene, določil na osnovi domnevno zelo natančnih risb (glej S. Brodar, M. Brodar 1983, t. 6-22). Na njih so prikazana samo lica konic, ne pa profili, kar je bila velika napaka, ki je hkrati s sumarno objavo mer (S. Brodar, M. Brodar 1983, 125-127) za 20 let zavrla napredovanje v preučevanju koščenih konic Potočke zijalke in povzročila, da je raziskovanje obtičalo na slepem tiru. Brezizhodnosti položaja se je zavedal tudi avtor kritike, kar je med vrsticami večkrat priznal v svojih razpravah, nazadnje tudi v sami kritiki, ko pravi, da tipologija koščenih konic še ni dognana.

Ker sem pri razvijanju metode izhajal iz objavljenih risb, sem analiziral lica konic, kar je razvidno iz skic in statistik. Zato je neumestno vprašanje kritika, katero stran konice sem imel v mislih, ko sem analiziral obliko in določal eventualne tipe.

Pri nadaljnjem podrobnejšem preučevanju vzorca koščenih konic Potočke zijalke sem te lastnoročno izmeril v Pokrajinskem muzeju v Celju, predvsem terminalni (distalni) del in debelino. Druge mere sem povzel po M. Brodarju, takšne kot so shranjene v arhivu IzA. Ugotovil sem, da je M. Brodar pri konicah, ki so v preseku usločene, meril pri debelini višino loka namesto debeline kostne lu-

Tab.1: Mere koščenih konic iz Potočke zijalke na podlagi objavljenih risb in direktnega merjenja. Mere na podlagi risb so označene s štev. 1 in so enake kot v kritiziranem članku. Druge so označene s štev. 2. Prikazane so tudi odstotkovne razlike med obema meritvama terminalnega dela.
Table 1: Measurements of bone points from Potočka zijalka based on published sketches and direct measurement. Measurements based on sketches are marked with the number 1 and are identical to those in the criticised article. The remainder are marked with the number 2. The percentage differences between the two measurements of the distal part are also shown.

0	1	2	3	4	5	6	7	8	9
Inv. štev. Inv. no.	Dolžina rekon. 1 Reconstr. Lengtrh 1	Dolžina dist. 1 Distal length 1	Širina 1 Width 1	Dolžina rekon. 2 Reconstr. Length 2	Dolžina dist. 2 Distal length 2	Širina 2 Width 2	Razlika 5-2 (%) Difference 5-2 (%)	Velikost Size	Oblika Shape
75	227	148	30	230,0	155	31,0	4,7	large	spindle
2	165	96	19	163,0	107	18,5	11,5	large	spear
5	129	56	15	129	56	15	0,0	medium	unclassified
10	101	59	14	102,0	55	15,0	-6,8	small	spindle
12	120	70	20	*120,0*	*72*	*20,0*	2,9	medium	spear
30	134	82	15	132,0	81	16,0	-1,2	medium	spindle
31	191	138	19	188,0	136	19,0	-1,4	medium	spindle
35	145	86	11	144,0	92	12,5	7,0	medium	spindle
37	185	111	19	184,0	117	19,5	5,4	large	spindle
42	189	113	16	190,0	125	16,5	10,6	large	spindle
47		132	17	*210,0*	132	17,0		large	unclassified
50	**110**	**70**	**14**	**109,0**	**78**	**15,5**	**11,4**	**medium**	**spindle**
52	98	67	10	98,0	76	9,8	13,4	medium	spindle
53	**175**	**112**	**21**	**174,0**	**118**	**22,0**	**5,4**	**large**	**spear**
56	146	115	19	*146,0*	110	18,0	-4,3	large	spear
61	123	71	14	123,0	79	13,0	11,3	medium	spear
64	166	109	17	166,0	96	17,0	-11,9	large	spindle
65	**98**	**53**	**12**	**99,0**	**50**	**13,5**	**-5,7**	**small**	**spindle**
66		138	15	*210,0*		15,6		large	spear
67	90	65	11	90,0	64	10,6	-1,5	small	spear
70	133	92	12	132,0	89	12,0	-3,3	medium	spear
72	100	62	9	98,0	64	9,0	3,2	small	spindle
80	120	61	20	117,0	53	20,0	-13,1	small	spindle
82	141	106	19	140,0	110	20,0	3,8	large	spindle
90	121	73	19	*126,0*	77	19,0	5,5	medium	spear
92		115	12	*185,0*	115	12,5		large	spindle
99	113	59	15	103,0	64	15,0	8,5	small	spindle
100	111	70	14	111	70	14	0,0	medium	unclassified
101	**114**	**56**	**17**	**113,0**	**60**	**17,8**	**7,1**	**small**	**spindle**
102	40	30	6	40,0	29	6,0	-3,3	very small	spindle
104		72	19	*130,0*	72	20,0		medium	spear
105	102	55	11	100,0	56,0	12,0	1,8	small	spindle
106		145	17	*200,0*	145	17,0		large	unclassified
109	151	86	15	150,0	90	16,0	4,7	medium	spindle
122		58	22		58	23,0		small	unclassified
124	145	82	14	143,0	89	15,0	8,5	medium	spindle
134	168	84	23	168,0	90	25,0	7,1	medium	spindle

Opomba: Vse mere so v mm. Krepki tisk so cele konice, ležeči pa negotove rekonstrukcije po M. Brodarju.
Note: All measurements are in mm. In bold are complete points. In italic are uncertain reconstructions according to M. Brodar.

pine, kar se mi zdi pravilneje. S pomočjo debeline lahko namreč ocenim vložek dela pri izdelavi konice, ki je premo sorazmeren z debelino kostne lupine. Od vloženega dela je med drugim odvisna odločitev o popravilu poškodovane konice.

Mere obeh meritev (na podlagi risb in predmetov) so prikazane v tab. 1. Vidna so odstopanja, ki pri dolžini terminalnega dela znašajo od -11,9 % do +13,4 %.

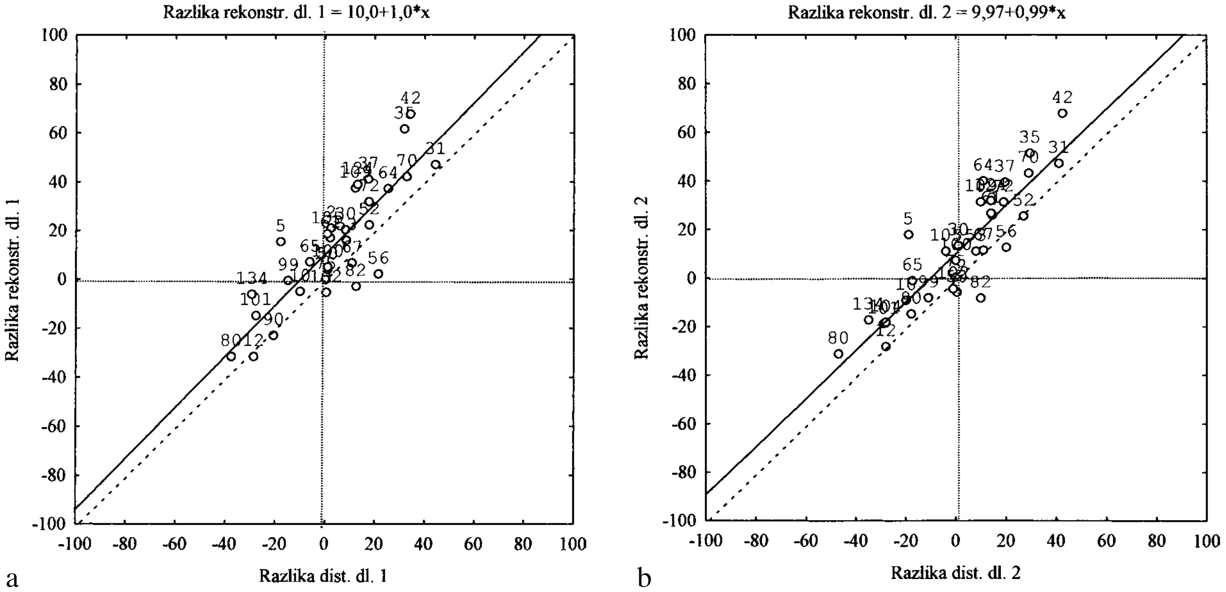
Zaradi jasnosti ponavljam definicijo terminalnega dela, ki so ga podobno opredelili že drugi pred mano (Albrecht et al. 1975, sl. 2). To je aktivni del konice, ki je brezpogojno štrlel iz toporišča in sega od mesta, kjer se konica pričně ožiti, pa do špice.

Zato trdim, da se ta del da izmeriti vsaj z natančnostjo ±10 %.

Trditev kritike, da se dasta nedvoumno določiti samo širina in dolžina (mišljena je rekonstruirana dolžina), je zavajajoča, saj je terminalna dolžina potemtakem dvoumna mera. To pa glede na podano definicijo ne drži. Vendar v tem primeru stvar ni samo v tem, ali je konkretna meritev dvoumna ali nedvoumna, temveč tudi v njeni natančnosti. Če želi biti kritika objektivna in verodostojna, bi morala dokazati, da netočne meritve, predvsem dvoumnih delov, vplivajo na rezultat, ki sem ga dobil z objavljeno metodo na podlagi regresijske analize. Ker tega ni storila, objavljam sicer nepotreben preizkus rezultata regresijske analize na podlagi dveh različnih meritev koščenih konic.

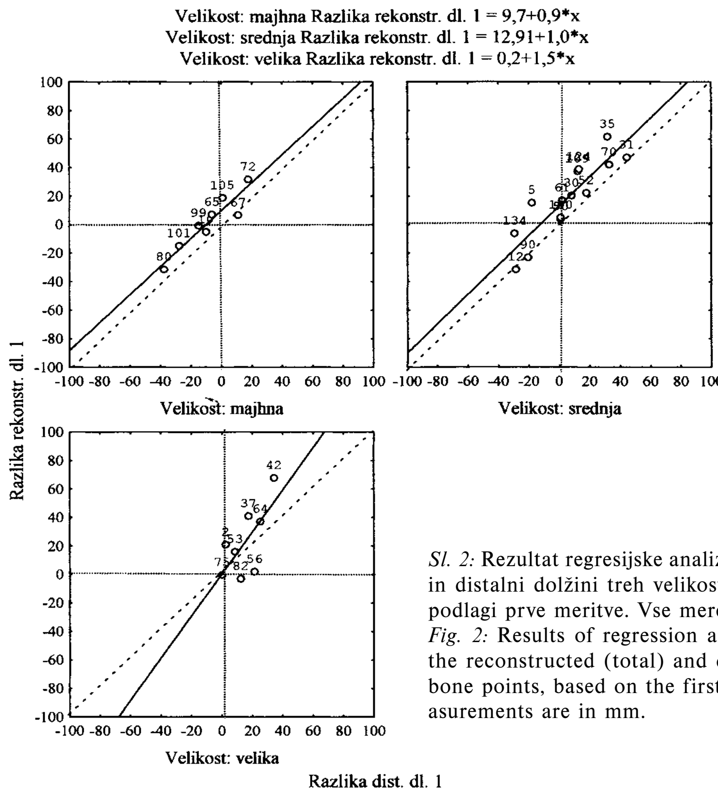
Pred tem pa še nekaj besed o kritiziranem medialnem delu, ki je domnevno odigral pomembno vlogo v razvoju koščenih konic. Njegova dolžina se resnično ne da izmeriti, zlasti če gre za del, ki je enkrat štrlel iz toporišča, drugič pa ne, kar je moja definicija. Zato sem ga izračunal, to pa je kritika spregledala. Na referenčni konici namreč nimam medialnega dela oz. tega namenoma nisem razmejil. Prav tako nimam razmejenga bazalnega dela, ki je bil zagotovo vsajen v toporišče. Ker se medialni in bazalni del domnevno dopolnjujeta kot različna dela, ki sta bila vsajena v toporišče, sta resnično dvoumne narave. Vendar se dasta izračunati največja in najmanjša dolžina domnevnega nasadišča in matematično natančno arbitrarno določiti bazalni del in medialni oz. odstopanje medialnega dela od referenčne konice. To odstopanje je za razvoj koščenih konic pomembnejše kot npr. odstopanje terminalnega dela, ki je vezano zgolj na velikost plena. Zakaj je medialni del tako pomemben je razvidno iz kritiziranega članka.

Če analiziram mere obeh meritev in uporabim analizo variance za ugotavljanje razlik, ki nastanejo pri ponavljanju meritev iste stvari (Repeted measures ANOVA, STATISTICA 6 StatSoft 2001), ugotovim, da med merami prve in druge meritve ni statistično značilnih razlik (p = 0,005). Zato je tudi regresijska analiza, s katero sem primerjal razliko terminalne dolžine z razliko rekonstruirane (cele) dolžine referenčne konice štev. 75, dala praktično identičen rezultat (*sl. 1 a,b*), ki ga tokrat ne interpretiram.



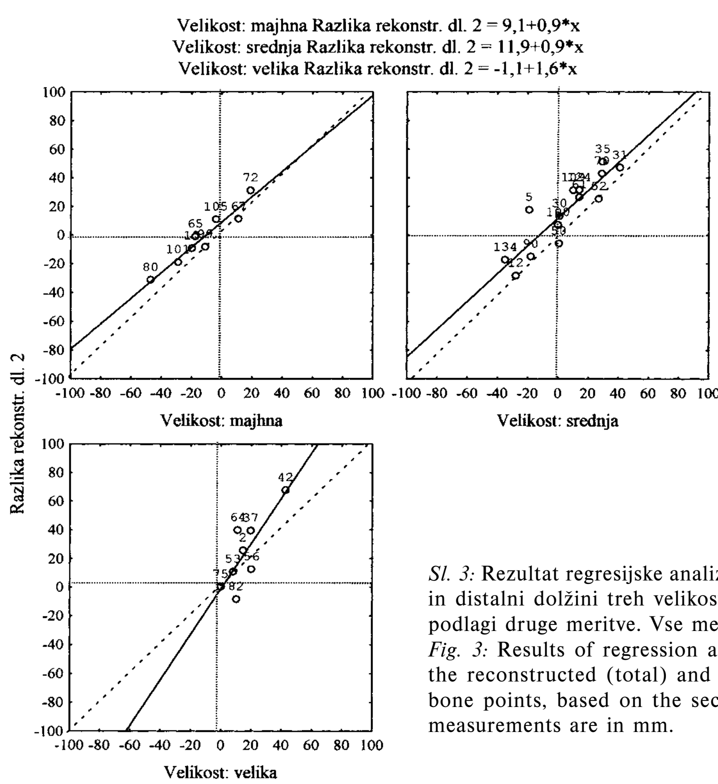
Sl. 1a,b: Primerjava rezultata regresijske analize razlik v rekonstruirani (celi) in distalni dolžini koščenih konic, narejene na podlagi prve (a) in druge (b) meritve. Vse mere so v mm.

Fig. 1 a,b: Comparison of results of regression analysis of differences between the reconstructed (total) and distal length of bone points, made on the basis of the first (a) and second (b) measurements. All measurements are in mm.



Sl. 2: Rezultat regresijske analize razlik v rekonstruirani (celi) in distalni dolžini treh velikosti koščenih konic, narejene na podlagi prve meritve. Vse mere so v mm.
Fig. 2: Results of regression analysis of differences between the reconstructed (total) and distal lengths of three sizes of bone points, based on the first set of measurements. All measurements are in mm.

Kritika torej nima prav, ko spodbija metodo in kriterije za izbor podatkov. Metoda je dovolj robustna, da prenese odstopanja ±10 % pri vhodnih podatkih. Pri takšni toleranci ne more biti sporno določanje meje med distalnim in medialnim delom, ki je predmet kritike.



Sl. 3: Rezultat regresijske analize razlik v rekonstruirani (celi) in distalni dolžini treh velikosti koščenih konic, narejene na podlagi druge meritve. Vse mere so v mm.
Fig. 3: Results of regression analysis of differences between the reconstructed (total) and distal length of three sizes of bone points, based on the second set of measurements. All measurements are in mm.

Ker vse kaže, da kritika ni dojela bistva predlagane metode, ki je v standardizaciji metričnih podatkov, ki obdržijo prvotni merski sistem in absolutne vrednosti; namesto brezmerskega sistema, ki bi ga dobil, če bi podatke standardiziral s pomočjo statističnih parametrov, sem koščene konice tokrat razdelil po velikosti (*tab. 1*). Kriterij je bila dolžina terminalnega dela. Zelo majhne konice imajo terminalni del dolg do 45 mm, majhne konice od več kot 45 mm do 65 mm, srednje od več kot 65 mm do 95 mm in velike daljši od 95 mm.

Rezultati regresijske analize, ki upošteva tri velikosti (majhno, srednjo in veliko), se pri obeh meritvah praktično ne razlikujejo (*sl. 2 in 3*). Pač pa lahko ugotovim naslednje: Majhne konice so najbolj standardizirane, velike pa najmanj. Dolžina terminalnega dela narašča od majhnih konic do velikih.

Vsega tega ni mogoče ugotoviti na podlagi nestandardiziranih podatkov, ki so prikazani na *sl. 4,* ker se posamezni deli koščenih konic večajo proporcionalno z njihovo velikostjo. Dosedanji raziskovalci pa so vsi po vrsti operirali z nestandardiziranimi podatki (Albrecht et al. 1972; M. Brodar 1985; Hahn 1988) razen morda Clémenta in Leroy-Prosta (1977). Na podlagi takšnih podatkov je nemogoče ugotoviti nekatere značilnosti vzorca, ki lahko bistveno vplivajo na reševanje vprašanja razvoja koščenih konic in posredno na vprašanje tipologije. Najslabše od vsega pa je, da se na podlagi takšnih podatkov vsa vprašanja relativizirajo, kar pripelje celotno razpravo v slepo ulico.

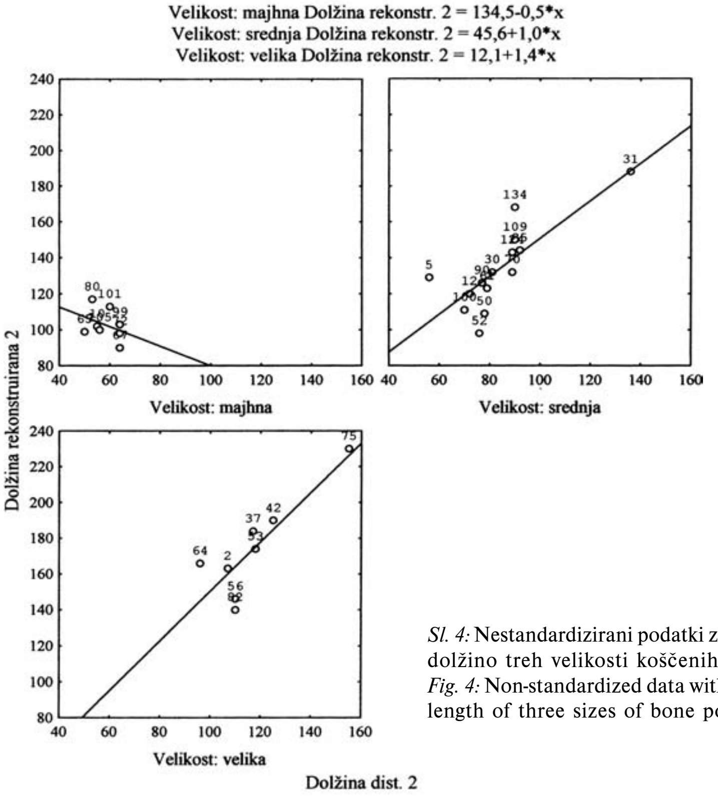
V kritiki se omenja tudi debelina, ki je v članku ne obravnavam, češ da sem zanemaril podatek, ki je odločilen za tip konice. M. Brodar (1985) je pri analizi vzorca koščenih konic iz Mokriške jame (3 konice!) in Potočke zijalke (83 konic) ugotovil, da ima vsako najdišče svoj tip konice. Kriterij za razlikovanje naj bi bila poleg širine tudi debelina. Vendar je iz objavljenih Brodarjevih diagramov jasno razvidno, da se konice z obeh najdišč razlikujejo samo v širini. Zato sem se vprašal, kakšno vlogo bi lahko imela debelina?

Ugotovil sem, da doslej ni bilo nikjer niti z besedico omenjeno, da bi debelina kakor koli vplivala tudi na ločevanje koščenih konic v vzorcu iz Potočke zijalke.

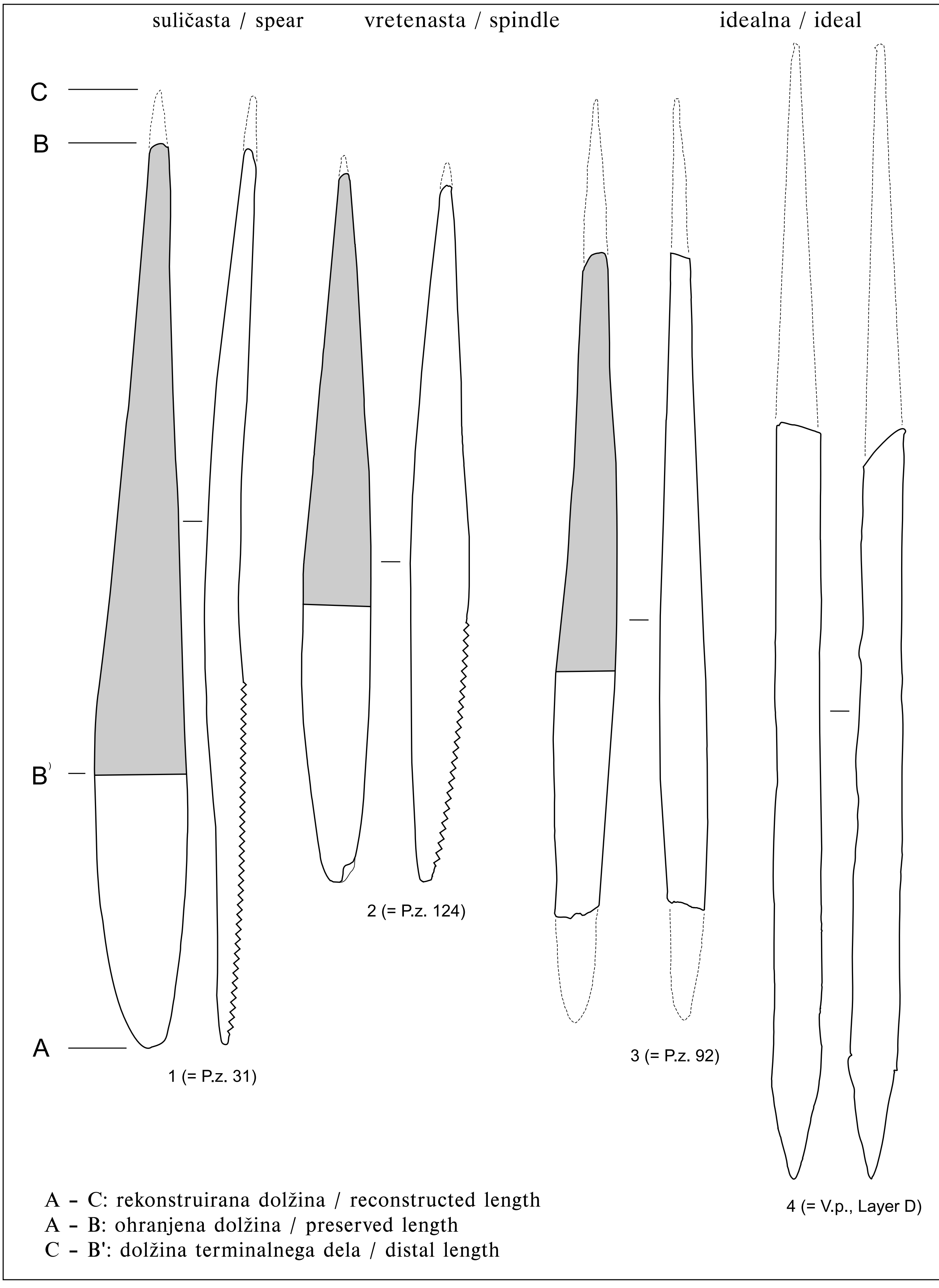
Dejansko je debelina odigrala pomembno vlogo pri razvoju konic, natančneje njihovega profila. To sem ugotovil prav na vzorcu iz Potočke zijalke (113 konic, med katerimi so tudi konice, katerih mere so objavljene v *tab. 1*), ki je edini dovolj velik za uporabo analitske statistične metode.

V nadaljevanju se bom nekoliko oddaljil od kritike, vendar bom pokazal, kako lahko z ustrezno metodo potrdim ali ovržem določeno trditev.

Predpostavljam, da je razvoj koščenih konic potekal skladno z reševanjem težav, povezanih s trdnostjo in prebojnostjo. Trdnost se povečuje z



Sl. 4: Nestandardizirani podatki z rekonstruirano (celo) in distalno dolžino treh velikosti koščenih konic. Vse mere so v mm.
Fig. 4: Non-standardized data with reconstructed (total) and distal length of three sizes of bone points. All measures are in mm.



Sl. 5: Osnovne oblike koščenih konic. 1-3: Potočka zijalka (Slovenija) (S. Brodar, M. Brodar 1983: t. 14: 31; t. 9: 124; t. 10: 92); 4: Velika pećina (Hrvaška) (Malez: neobjavljena konica iz plasti d).
Fig. 5: Basic shapes of bone points. 1-3: Potočka zijalka (Slovenia)(S. Brodar, M. Brodar 1983: t. 14: 31; t. 9: 124; t.10: 92); 4: Velika pećina (Croatia) (Malez: unpublished bone spear-head from layer d).

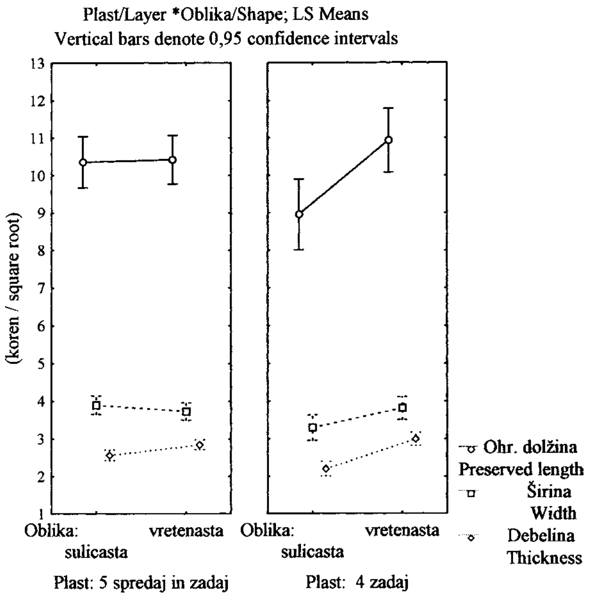
večjo širino in/ali debelino. Pri širini se trdnost povečuje linearno, pri debelini pa na kvadrat (Horusitzky 2004). Da to drži v konkretnem primeru, se zlahka prepričamo, če izračunamo obliko regresijske črte za odnos širina:teža in debelina:teža, pri čemer teža predstavlja maso, ki jo lahko povežemo s trdnostjo. Večino odnosa širina:teža pojasni regresijska premica. Gre torej za linearni odnos med širino in težo, ki predstavlja trdnost. Večino odnosa debelina:teža pojasni krivulja oz. kvadratna funkcija. Iz tega sledi, da z večjo debelino koščene konice ubijemo dve muhi na en mah: če konico zadebelimo in obenem zožamo na še dopustno mejo, povečamo hkrati trdnost in prebojnost. Pri širjenju konice kaj takega seveda ni mogoče. Nasprotno, s širjenjem konice se zmanjšuje njena prebojnost, hkrati nastopijo tudi težave z nasaditvijo (glej Horusitzky 2004). Idealna konica ima torej obliko svinčnika in jo je tako kot svinčnik mogoče večkrat ošiliti. Takšna konica omogoča tudi idealen način nasajanja v idealno toporišče. Idealno toporišče je cev. Če ima cev še mehak stržen kot npr. bezgovo steblo, lahko konico enostavno zabijemo v toporišče.

Ko sem tako postavil teorijo razvoja, si nisem mogel kaj, da je ne bi preveril na gradivu. Tokrat sem kot glavno metodo izbral analizo variance (ANOVA/MANOVA), ki omogoča hkrati primerjati variabilnost znotraj faktorjev vzorcev (npr. plasti, oblike konice ipd.) in med njimi, rečeno poenostavljeno. Teorijo sem lahko potrdil samo na podlagi naslednje stratigrafske sheme, ki združuje najdbe iz sprednjega in zadnjega dela jame. Najstarejše so najdbe v plasti 7 spredaj, sledijo najdbe iz plasti 5 spredaj in zadaj, najmlajše so najdbe iz plasti 4 zadaj.

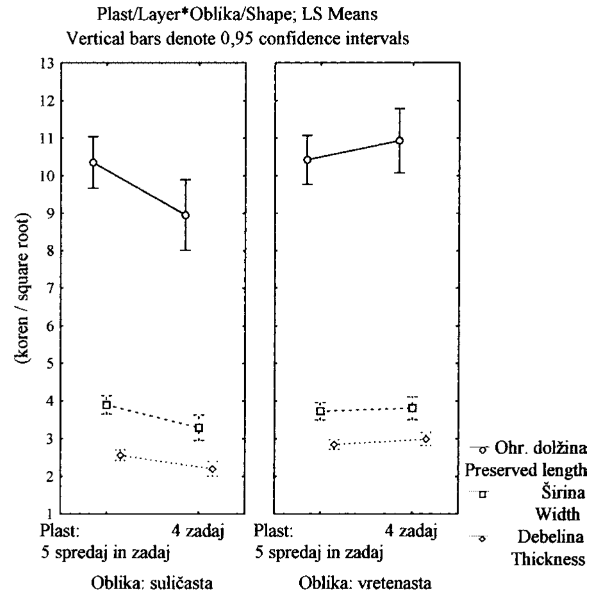
Večino koščenih konic vzorca iz Potočke zijalke sem lahko na podlagi profilov razdelil v dve skupini. Pripadajoče konice sem imenoval "suličaste" in "vretenaste" (*sl. 5*). Takšno delitev je prvi predlagal F. Horusitzky (2004).

Suličaste konice (35 primerkov) so izdelane iz relativno tanke kostne lupine in so zato enakomerno debele v skoraj celi dolžini. Njihov profil je podoben profilu lista kovinske sulice. Najširše so v predelu, kjer so se domnevno stikale s toporiščem. Kostna lupina je komaj kaj spremenjena.

Vretenaste konice (49 primerkov) so izdelane iz relativno debele kostne lupine, ki je najdebelejša (nespremenjena) v medialnem delu in umetno stanjšana (spremenjena) proti obema koncema. Njihov profil je podoben profilu vretena oz. licu večine konic v vzorcu.



Sl. 6: Rezultat faktorske analize variance oblike koščenih konic v povezavi s stratigrafijo. Mere sem transformiral s korenjenjem, da sem dobil zanesljivo normalno porazdelitev, potrjeno z W-testom Shapira in Wilka (p = 0,17 do 0,98).
Fig. 6: The results of factorial analysis of variance in the shapes of bone points in relation to stratigraphy. I transformed the measures by square root extraction in order to get a significant normal distribution, confirmed by the Shapiro-Wilk's W test (p = 0.17 to 0.98).



Sl. 7: Glej napis pri *sl. 6*.
Fig. 7: For explanation see *Fig. 6*.

Predlagani skupini konic se na podlagi faktorske analize variance (ANOVA/MANOVA) in analize kovariance (ANCOVA/MANCOVA) metrično razlikujeta po debelini, širini in dolžini medialnega dela ter pogojno v ohranjeni dolžini. Pri terminalni dolžini ni razlik. Vretenaste konice so zanesljivo debelejše in ožje (ANCOVA/MANCOVA, p < 0,001), imajo daljši medialni del ter pogojno večjo ohranjeno dolžino (ANOVA/MANOVA, p = 0,01 in 0,08). Razlike v debelini, širini in dolžini medialnega dela so primarne, razlika v ohranjeni dolžini pa je sekundarna, ker je odvisna od debeline, širine in dolžine medialnega dela.

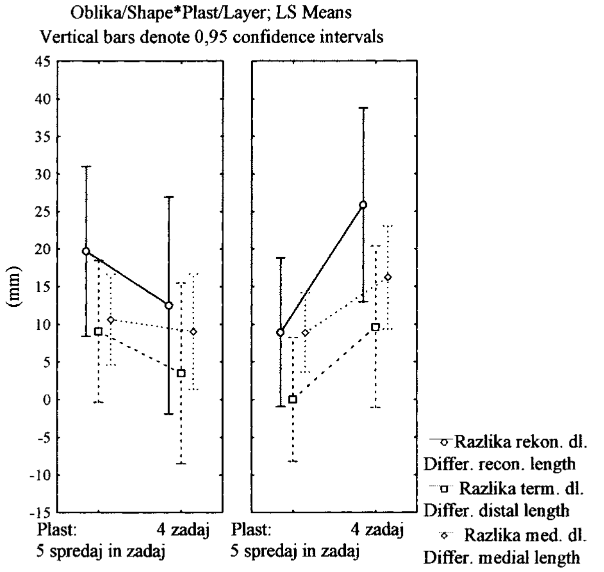
Faktorska analiza variance suličastih in vretenastih konic, pri kateri sem primerjal združeni plasti 5 spredaj in zadaj s plastjo 4 zadaj, ki je mlajša od plasti 5 zadaj, je pokazala, da so primarne razlike razvojne narave (ANOVA/MANOVA, p = 0,03). Namreč: v plasti 5 spredaj in zadaj so vretenaste konice samo debelejše od suličastih, v plasti 4 zadaj pa so tudi širše in daljše (*sl. 6*). Razen tega je razlika v debelini v plasti 4 zadaj bistveno večja kot v plasti 5 spredaj in zadaj.

Suličaste konice so sčasoma nazadovale: postajale so vse ožje in tanjše, zaradi česar se je zmanjšala tudi ohranjena dolžina, ker so bile takšne konice manj trdne. Pri vretenastih konicah je bilo ravno obratno: postajale so predvsem debelejše, pa tudi širše, zaradi česar se je rahlo povečala ohranjena dolžina (*sl. 7*). Vendar je treba poudariti, da je za vretenaste konice statistično značilno samo povečanje debeline (p < 0,05).

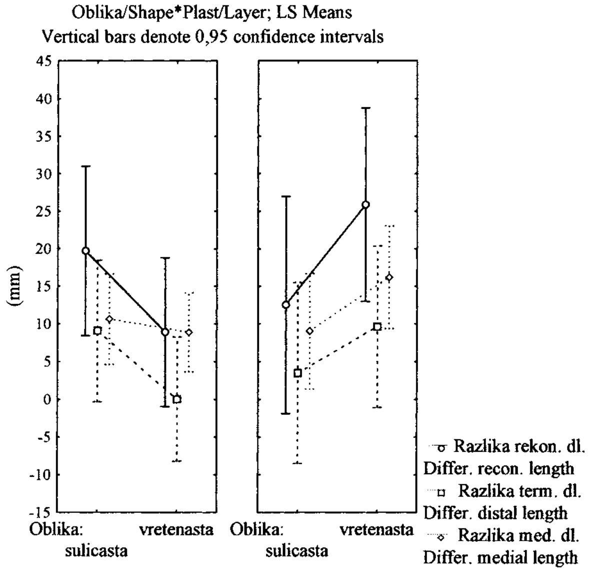
Rezultat, ki je primerljiv z rezultatom, kot ga kažeta sl. 6 in 7, sem dobil tudi s faktorsko analizo variance razlik v rekonstruirani dolžini, terminalni dolžini in medialni dolžini od standardne konice štev. 75. Pri tem je treba poudariti, da so vse dolžinske mere med seboj močno odvisne, zaradi česar dajejo podobne rezultate.

To pa ne drži za razliko v medialni dolžini, ki se spreminja po svoje, vendar razvojno skladno z domnevno vlogo medialnega dela, ki je bila: omogočiti večkratno šiljenje poškodovanega terminalnega dela. S pomočjo medialnega dela se je namreč ohranjala stalna dolžina aktivnega terminalnega dela ne glede na poškodbe, do katerih je nujno prišlo pri uporabi koščenih konic.

Podaljševanje medialnega dela je značilno edino za vretenaste konice, pri katerih je kronostratigrafsko pogojena razlika tudi statistično značilna (*sl. 8*). Podatki za razliko medialne dolžine so statistično zanesljivo normalno porazdeljeni (W-test Shapira in Wilka, p = 0,11 do 0,99). Do podaljševanja medialnega dela je prišlo v plasti 4 zadaj, ko so se vretenaste konice v dolžini medialnega dela tudi ločile od suličastih (*sl. 9*).



Sl. 8: Rezultat faktorske analize variance razlike rekonstruirane dolžine, terminalne in medialne dolžine suličastih in vretenastih konic v plasti 5 spredaj in zadaj ter plasti 4 zadaj. Razlika je absolutno odstopanje od standarda, ki ga predstavlja konica štev. 75 z vrednostjo 0.
Fig. 8: The result of factorial analysis of variance of the difference in reconstructed length, distal and medial length of spear shaped and spindle shaped points in layer 5, front and back, and layer 4 back. The difference is an absolute deviation from the standard, which is represented by point number 75 with a value 0.



Sl. 9: Glej napis pri *sl. 8.*
Fig. 9: See *Fig. 8.*

Domneva o šiljenju poškodovanih konic je bila tudi deležna kritike. Postavljeno je bilo tehtno vprašanje, zakaj ni bilo popravljenih vsaj 60 konic z malenkostno poškodovanim terminalnim delom, ki v glavnem izvirajo iz ozadja jame. Če so te konice kljub poškodbi dejansko služile svojemu namenu, kot trdi kritik, lahko vprašanje obrnem. Kaj delajo tako številne uporabne konice med enako številnimi neuporabnimi odlomki? Če so jih shranili v jami, so jih lahko shranili tudi z namenom, da jih pozneje popravijo. Vsekakor človek lažje pogreša poškodovano kot nepoškodovano konico, ki jih je v celotni zbirki samo 5 ali slabe 4 %.

Stratigrafsko potrjene spremembe na koščenih konicah (povečevanje debeline, zmanjševanje širine, podaljševanje medialnega dela) dokazujejo, da je moja teoretska razvojna shema pravilnejša od drugih predlaganih shem oz. tipologij, ki niso kronološko preverjene. Njeno pravilno naravnanost potrjuje tudi poznejši razvoj, ki je že v gravetjenu privedel do opisane optimalne oblike koščene konice (*sl. 5:* 3), kakršno npr. poznamo iz Vindije in Velike pećine (*sl. 5:* 4) (Malez 1967; 1988).

Na podlagi tukaj prikazanih kratkih izvajanj lahko naredim nekaj začasnih sklepov:

1. Sestavljena arheološka in statistična metoda ponuja nove možnosti za reševanje tipološko-razvojnih vprašanj, povezanih s koščenimi konicami. Morda ponuja tudi izhod iz slepe ulice, v kateri se je znašla tipologija.

2. Gradivo Potočke zijalke kliče po temeljiti reviziji. Poleg velikosti in oblike koščenih konic je treba preučiti tudi poškodbe, kar so vse teme, o katerih se je doslej komaj kaj pisalo.

3. Na novo bo treba opredeliti tipe koščenih konic, saj je že sedaj jasno, da dosedanja definicija tipa konice iz Potočke zijalke ni dobra, ker ne upošteva razvoja in variabilnosti. Gre za statični model, medtem ko je povsem razumljivo, da so se konice stalno razvijale (spreminjale) v času in prostoru.

4. Če hočemo preučevati in doumeti variabilnost koščenih konic, moramo razviti ustrezne analitske metode.

Izvirni analitski postopki, opravljeni na gradivu iz Potočke zijalke, se žal ne dajo ponoviti na gradivu iz drugih najdišč in tako se tudi ne da potrditi ali ovreči pravilnosti teorije, ki je nastala v treh korakih: 1. z analizo celotnega gradiva iz Potočke zijalke, 2. s teorijo razvoja koščenih konic in 3. s preizkusom teorije. Edina izjema je morda najdišče La Ferrassie v Franciji (D. Peyrony 1934), ki vsebuje dovolj veliko število bolje ohranjenih konic. Primerjava obeh najdišč je bila že narejena, vendar s pomočjo drugačne metodologije (Hahn 1988). Zato ni bilo za Potočko zijalko ugotovljeno nič od tega, kar je podano v tem zagovoru.

Tukaj predstavljeni preliminarni rezultati so samo del rezultatov obsežne analize vzorca koščenih konic iz Potočke zijalke, ki bodo objavljeni šele po treznem premisleku, predvsem pa, ko bo domača stroka doumela in razumela pričujoči zagovor in bila voljna sprejeti novo metodologijo.

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In defence of morphometric analysis of bone points

Translation

The criticism denoted the basic idea, i.e., the entire methodology for classifying bone points presented in the article ”Morphometric analysis of early bone points in connection with finds of bone points from Divje Babe I.” (Turk 2002), as mistaken (Brodar 2003). This did not refer to the statistical method itself, but its use in this case. The criticism focused on determining the measurements of bone points, saying that they are inaccurate and subjective. If this is true, then the claim of mistaken use of the new method for classifying bone points is also true and, consequently, also the results that this method enables. For the sake of the profession, I have an obligation to show that this criticism is unjustified and, in my opinion, a result of a lack of understanding of the basic principals of the statistical method. Other critical remarks are not so serious, so I will not concern myself with them in detail.

I have stressed more than once that the most crucial thing in research is the method. This is also true for the typology of bone points, which has been the subject of many discussions. A good method can lead to results despite inaccurate data. On the other hand, a bad method or no method at all will not lead to results, despite extremely accurate data and work.

In the analysis of material for the supposedly contentious article, I proceeded from the above. I therefore determined the measurements of the bone points, which had not to date been published, on the basis of presumably very accurate sketches (see S. Brodar and M. Brodar 1983, plates 6-22). They show only the faces of the points, and not the profiles, which was a major mistake that, together with the summary publication of the measurements (S. Brodar and M. Brodar 1983, 125-127) hindered the progress of research of bone points in Potočka zijalka for the next 20 years, bringing research to a dead halt. The author of the criticism realized the cleft stick situation, which he admitted more than once between the lines of his publications and even in the criticism itself, when he says that the typology of the bone points is not yet established.

Because I proceeded from the published sketches in developing the method, I analysed the face of the points, which is evident from my sketches, and statistics. The question in the criticism of which side of the point I had in mind when I was analysing the shape and defining possible types, is therefore misplaced. In further more detailed study of the sample of bone points from Potočka zijalka, I measured them in the Regional Museum in Celje, in particular the distal (terminal) part and the thickness. I summarized the other measurements from M. Brodar, as kept in the Institute of Archaeology archive. I found that M. Brodar had measured points that were convex in cross-section at the thickness of the height of the arc, instead of the thickness of the cortical bone, which I think is more correct. With the aid of the thickness, we can in fact evaluate the input of work (energy) in the production of a bone point, which is fairly proportionate to the thickness of the cortical bone. Among other things, a decision on whether to repair a broken point depends on this input.

The two measurements (based on sketches and objects) are shown in *Table 1*. Deviations can be observed, which range from -11.9% to +13.4% for the length of the distal part.

For the sake of clarity, I will repeat the definition of the distal part, as it has similarly been defined by others before me (Albrecht et al. 1975, Fig. 2). This is the active part of the point, which certainly jutted out of the spear or lance shaft, and extended from the point at which the point started to narrow and up to the tip or apex.

I therefore assert that this part can be measured with an accuracy of at least ±10%. The critic's claim that only the width and length (meaning the reconstructed length) can be determined without doubt is misleading, because that would mean that the distal length is a dubious measurement. This is not so according to the given definition. The issue here is not just whether a specific measurement is doubtful or not, but also whether it is accurate. To be objective and credible, the critic should have proven that inaccurate measurements, especially of suspect parts, affect the result that I got with the published method based on regression analysis. Because this was not done, I am publishing an otherwise unnecessary test of the result of regression analysis based on two different measurements of bone points.

First, however, a few words about the criticised medial part, which presumably played an important role in the development of a bone point. Certainly its length cannot be measured, especially if that part sometimes jutted out of the shaft and sometimes did not, which is my definition. This is why I calculated it, which the critic overlooked. I have no medial part on the reference point, or I deliberately did not delineate it. Neither do I have a delineated basal part, which was certainly set in the shaft. Since the medial and basal parts presumably supplement each other as different parts implanted in the shaft, they are certainly of ambiguous nature. However the largest and smallest length of the part presumably fixed in the shaft can be calculated and the basal and medial parts can be arbitrarily determined with mathematical precision or the deviation of the medial part from the reference point. This deviation is more important for the development of bone points than, for example, the deviation of the distal part, which is relevant only to the size of the prey. Why the medial part is so important is clear from the criticised article.

If I analyse the two measurements and use analysis of variance to determine differences that occur with repetitions of measurements of the same thing (Repeated measurements ANOVA, STATISTICA 6 Stat Soft 2001), I can establish that there are no statistically significant differences between the first and second measurements ($p = 0.005$). Regression analysis, by which I compared the difference between the distal and reconstructed (total) length from reference point number 75, lead to practically identical results (*Fig. 1 a,b*), which I will not interpret.

The critic is therefore wrong to impugn the method and criteria for selecting the data. The method is robust enough to bear deviations of ±10% in the input data. Defining the boundary between the distal and medial parts within such a tolerance, which is the subject of criticism, cannot be disputed.

Since everything suggests that the critic did not understand the essence of the suggested method, which is the standardization of metric data, which retain the primary measuring system and absolute values, instead of a dimensionless system, as one would get if one standardized the data according to statistical parameters, I classified the bone points by size (*Table 1*). The criteria were the length of the distal part. The distal part of very small points is up to 45 mm long, of small points from 45 mm to 65 mm, of medium sized points from 65 mm to 95 mm and of large points longer than 95 mm.

The results of regression analysis taking into account the three sizes (small, medium and large), hardly differ with the two measurements (*Fig. 2* and *3*). However, I can establish the following: Small points are most standardized and large points are least standardized. The length of the distal part increases from small to large points.

None of this can be established on the basis of non-standardized data, which are shown in *Fig. 4,* because individual parts of the bone points increase proportionally with their size. All previous researchers, however, have operated with non-standardized data (Albrecht et al. 1972; M. Brodar 1985; Hahn 1988), with the possible exception of Clément and Leroy-Prost (1977). Based on such data, it is impossible to establish certain characteristics of the sample (e.g. studied collection), which can essentially affect solving the question of the development of bone points and indirectly the question of typology. Worst of all, based on such data, all questions are relativised, which leads the entire discussion to a blind alley.

The thickness is also mentioned in the criticism, which I do not deal with in the article, as though I had neglected this information, which is decisive for the type of the point. M. Brodar (1985) established in the analysis of samples of bone points from Mokriška cave = Mokriška jama (three points!) and Potočka cave = Potočka zijalka (83 points!), that every site has its own type of point. The criteria for distinguishing them are supposed to be width as well as thickness. However, it is clear from Brodar's published diagrams that the points from the two sites differ only in width. So I asked the question: what role could thickness have?

I established that nowhere has it ever been suggested that thickness could also affect distinguishing bone points within the Potočka zijalka sample.

In fact, thickness played an important role in the development of points, more specifically their profile. I established this on the sample from Potočka zijalka (113 points, including points whose measurements are published in *Table 1*), which is the only one large enough to use the analytical statistical method.

I am now going to digress from the criticism; however, I will demonstrate how I can prove or disprove a statement with the relevant method.

I am presuming that the development of bone points followed solutions to problems connected with strength and piercing power. Strength increases with greater width and/or thickness. With width, the strength increases linearly and with thickness by square (Horusitzky 2004). The truth of this can easily be tested in a specific case, by calculating the shape of the regression line for width to weight and thickness to weight, where weight represents the mass, which we can correlate with the strength. Most of the width:weight relation is explained by a straight regression line. Thus a linear relation between width and weight, which represents strength. Most of the thickness:weight relation is explained by a curved regression line or square function. Hence it follows that we kill two flies with one stroke with a thicker point: If we thicken and at the same time narrow the point to a still acceptable limit, we increase the strength and piercing power at the same time. This is not, of course, possible by widening the point. In contrast, when the point is widened the piercing power is reduced and problems also occur with shafting (see Horusitzky 2004). The ideal point is therefore pencil shaped and, like a pencil, can be repeatedly sharpened. A point shaped like this also enables the ideal method of shafting into the ideal shaft. The ideal shaft is a tube. If the tube has soft pith, like an elder stem the point can simply be driven into the shaft. Having put forward a theory of development, I was bound to test it against archaeological finds. This time I chose analysis of variance as my main method (ANOVA/MANOVA), which enables simultaneous comparison of the variability within factors of samples (for example layers, shape of the point etc.) and between them, put simply. I could only confirm the theory based on the following stratigraphic scheme, which combines finds from the front and back part of the cave. The oldest are the finds in layer 7 front, followed by finds from layer 5, front and back, and the most recent are finds from layer 4 back. I could divide most of the bone points from the Potočka zijalka sample, based on their profile, into two groups. I have called the points "spear shaped or flat" and "spindle shaped" (*Fig. 5*). This division was first suggested by F. Horusitzky (2004).

Spear shaped points (35 specimens) are crafted from a relatively thin cortical bone and are for that reason equally thick almost along the whole length. Their profile is similar to the profile of the blade of a metal lance-head. They are thickest in the part where they presumably jutted out of the shaft. The cortical bone is hardly changed.

Spindle shaped points (49 specimens) are crafted from thick cortical bone, which is thickest (unmodified) in the medial part and artificially thinned (modified) towards both ends. Their profile is similar to the profile of a spindle or the face of the majority of points in the sample.

Based on factorial analysis of variance (ANOVA/MANOVA) and analysis of covariance (ANCOVA/MANCOVA), the suggested groups of points differ in thickness, width and length of the medial part and, conditionally, in the preserved length. There are no differences in the distal part. Spindle shaped points are significantly thicker and narrower (ANCOVA/MANCOVA, $p < 0.001$), they have a longer medial part and, conditionally, greater preserved length (ANOVA/MANOVA, $p = 0.01$ and 0.08). Differences in thickness, width and length of the medial part are primary; the difference in preserved length is secondary since it depends on the thickness, width and length of the medial part. Factorial analysis of variance of spear shaped and spindle shaped points, by which I compared joint layers 5 front and back with layer 4 back, which is more recent than layer 5 back, indicated that the primary differences are of an evolutionary nature (ANOVA/MANOVA, $p = 0.03$).

Specifically: Spindle shaped points in layer 5, front and back, are thicker than spear shaped ones, in layer 4 back they are also wider and longer (*Fig. 6*). In addition, the difference in thickness in layer 4 back is essentially larger than in layer 5, front and back.

Spear shaped points regressed with time: they became narrower and thinner, because of which the preserved length was also reduced, because such points are not as solid. It was the opposite with the spindle shaped points: they became primarily thicker and also wider, because of which the preserved length increased slightly (*Fig. 7*). However, it must be stressed that only the increase of thickness is statistically significant for spindle shaped points ($p < 0.05$).

I got the same result, which is comparable to the results shown by *Figs. 6* and *7,* with factorial analysis of variance of the differences of the reconstructed length, distal length and medial length from standard point number 75. Here it must be stressed that all measurements are strongly dependent on each other, because of which they give similar results.

This is not true for the medial length, which changes in its own way, although evolutionarily according to the presumed role of the medial part, which was to enable multiple sharpening of a damaged distal part. In other words, the medial part helped retain a constant length of the active distal part, irrespective of damage, which was inevitable when using bone points. Lengthening of the medial part is uniquely typical of spindle shaped points, whereby the chronostratigraphically conditioned difference is also statistically significant (*Fig. 8*). Data for the difference of the medial length are statistically significantly normally distributed (Shapiro-Wilk's W test, $p = 0.11$ to 0.99). Lengthening the medial part occurred in layer 4 back, when the medial lengths of spindle shaped points were also distinguished from spear shaped ones (*Fig. 9*).

The assumption of resharpening damaged points was also criticised. The well-founded question was raised, why at least 60 points with minimal damage to the distal part originating from the back of the cave were not repaired. If these points served their purpose despite the damage, which is the claim of the critic, I can reverse the question. What is such a large number of useful points doing among an equally large number of useless fragments? If they were deposited in the cave, they could have been saved with the intention of being repaired later. In any case a person can do without a damaged point much easier than without undamaged points, of which there are only about 4 to 5% in the whole collection.

Stratigraphically confirmed changes in the bone points (increasing length, decreasing width, lengthening of the medial part) demonstrate that my theoretical evolutionary scheme is more correct than other suggested, chronologically untested, schemes or typologies. Its correctness is confirmed by later development, leading in the Gravettian to the already described ideal shape of bone spear-head (*Fig. 5:* 3), such as that from Vindija and Velika pećina in Croatia (*Fig. 5:* 4) (Malez 1967; 1988).

Based on the above, I can reach some temporary conclusions:

1. The combined archaeological and statistical method offers new possibilities for solving typological-evolutionary questions connected with bone points. It might also offer a way out of the dead end in which typology has found itself.

2. The material from Potočka zijalka calls for thorough revision. In addition to the size and shape of the bone points, damage must also be studied, all topics about which scarcely anything has been written.

3. The types of bone points will have to be redefined, since it is clear that the former definition of the type of point Potočka zijalka or Olševa point (S. Brodar, M. Brodar 1983) is inadequate in not considering development and variability. It is a static model, while it is entirely reasonable to assume that points were constantly developing (changing) in time and space.

4. If we are to study and understand the variability of bone points, we must develop suitable analytical methods.

Original analytic procedures developed on material from Potočka zijalka, can unfortunately not be repeated on material from other sites and thus confirm or disprove the correctness of the theory, which was the result of three steps: 1.) analysis of the complete material from Potočka zijalka, 2.) theory of the development of bone points and 3.) test of the theory. The only exception might be La Ferrassie site in France (Peyrony 1934), which contains sufficient better preserved points. A comparison of the two sites has already been made, but by means of a different methodology (Hahn 1988). So none of what is presented in this answer has been ascertained for Potočka zijalka.

The preliminary results presented here are only part of the results of an extended analysis of the sample of bone points from Potočka zijalka, which will be published only after sober reflection, but most of all when the local profession fully grasps the point of my writing and is willing to accept a new methodology.

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